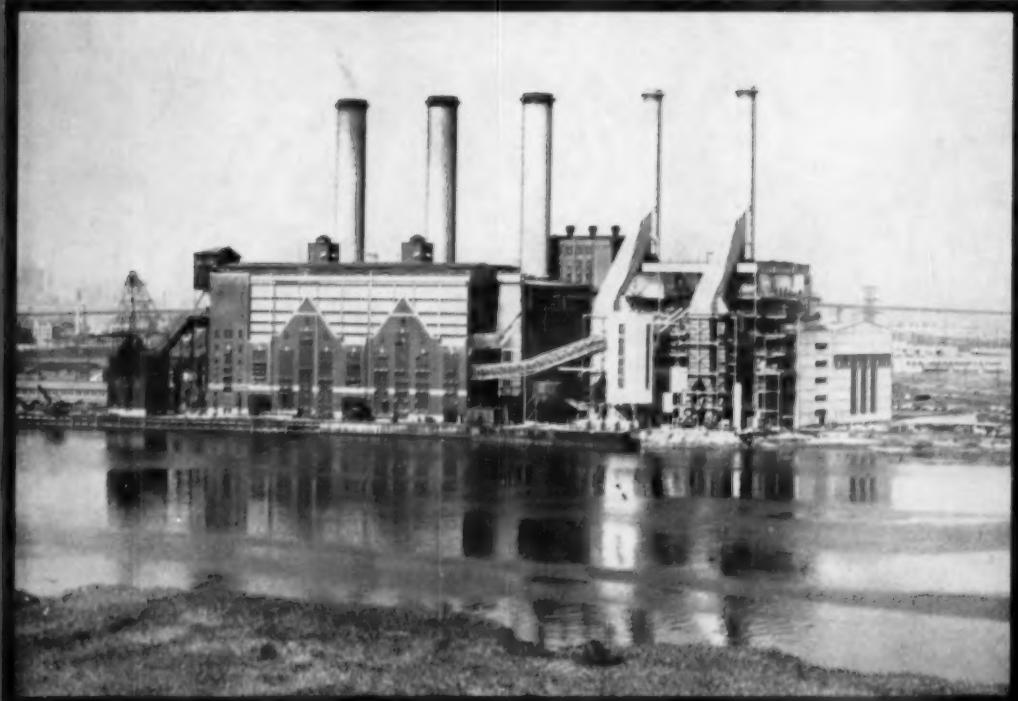


COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

January 1955



Kearny Generating Station of Public Service Electric & Gas Co.

The Present Status of Steam Properties

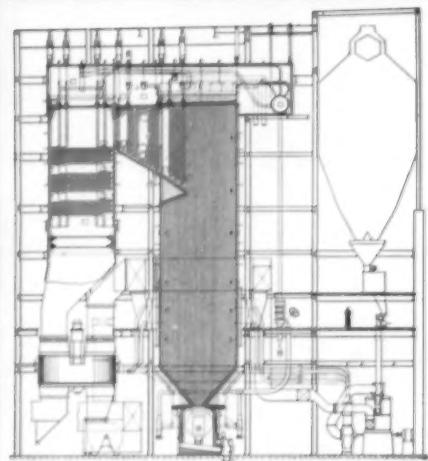
**Balancing Energy Needs Against
Byproduct Fuel at Sparrows Point**

Bare Tube Walls on Slag Tap Furnaces

Power Practices in 1954

PERFORMANCE RECORD CONTROLLED CIRCULATION BOILERS EASTLAKE PLANT

The Cleveland Electric Illuminating Co.



One of the three C-E Controlled Circulation Boilers now in service at Eastlake. Each serves a 100,000/125,000 kw turbine-generator operating at a throttle pressure of 1800 psi with a primary steam temperature of 1050 F., reheated to 1000 F.

Three C-E Controlled Circulation Boilers are now in service at Eastlake Plant of The Cleveland Electric Illuminating Company. The first of these started September 17, 1953; the second, December 21, 1953; and the third, August 26, 1954. Performance records of Boilers No. 1 and No. 2 for periods of 12 months and 8 months respectively show the following principal results:

AVAILABILITY	Boiler No. 1	98.1%
	Boiler No. 2	98.4%
(In service or available. Not considered available while down for inspection or repair, or while in process of starting up or shutting down.)		
USE FACTOR	Boiler No. 1	91.3%
	Boiler No. 2	92.2%
(Hours of serviceable hours to total hours.)		
CAPACITY FACTOR	Boiler No. 1	113.8%
	Boiler No. 2	116.3%
(Rate of energy delivery output — net kw — to maximum capacity of turbine-generator.)		
EFFICIENCY	Boiler No. 1	89.2%
	Boiler No. 2	89.4%
Nominal efficiency = 88.4%.		
100%		

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.



8-777

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 26

No. 7

January 1955

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COMBUSTION published its annual index in the June issue and is indexed regularly by Engineering Index, Inc.

GERALD S. CARRICK
Business Manager

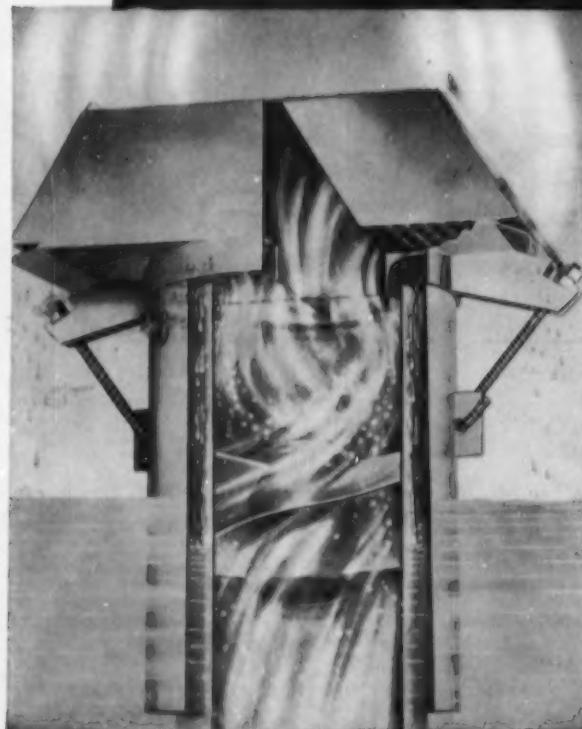
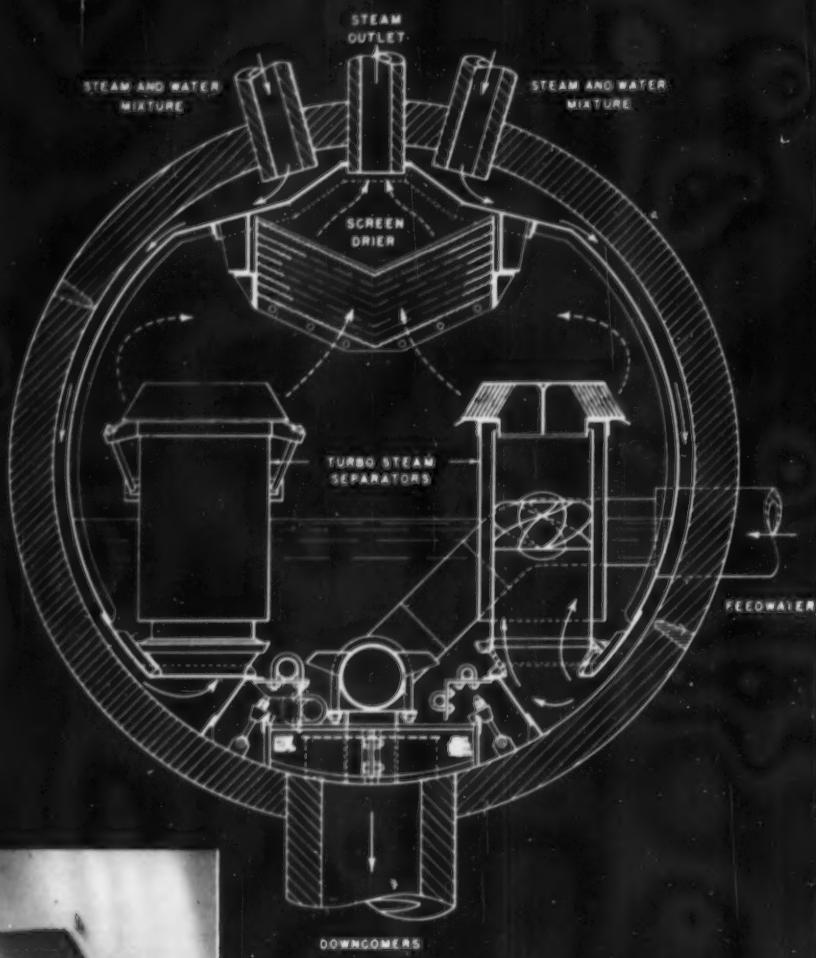
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BPA

Printed in U. S. A.



How it works

Steam-water mixture enters the top of the drum through nozzles discharging into an annular space formed by internal baffles. Flow of the mixture is directed downward behind symmetrical baffles around the entire drum surface, maintaining a uniform drum-wall temperature, and then into the Turbo-Separators. The latter contain a center core and vanes which give the mixture a spinning or centrifugal motion, thereby throwing the water to the outer edges of the inner tube. Directly above the directional vanes and cores there is a skim-off lip which directs the water over the top of the inner tube and thence through the annular space to the drum. This is the primary separation stage. The relatively dry steam then passes through two opposed banks of closely spaced corrugated plates, which change the direction of the steam many times and throw out much of the remaining water. This is the secondary separation stage. The third and final stage of purification is accomplished in the screen drier.

MEET THE TURBO-SEPARATOR

... the best friend a turbine ever had

To anyone concerned with the subject of steam purity and quality, boiler drum internals are of great significance. For that reason, we would like to have you meet the C-E Turbo-Separator, long an integral part of C-E Utility Boilers, but normally well concealed from view within the dark recesses of the steam drum.

The true test of any system of drum internals lies in what it can do with the combination of water, steam and solids it must handle — not alone under steady base load conditions — but under all operating conditions. Sudden load fluctuations, change in boiler water level and increased solids concentration in boiler water due to condenser leakage are three common occurrences that can greatly affect the relationship of solids to steam.

Whether the concentration of solids in boiler water averages less than 100 ppm or even more than 1000 ppm — or whether it fluctuates anywhere between — the C-E Turbo-Separator *maintains* steam purity and quality well within satisfactory limits.

To be more specific — test results in a number of cases have shown less than .5 ppm and in some instances as low as .1 ppm. These results are supported by the fact that in no plant where Turbo-Separators are installed has there been any measurable loss of turbine capacity due to deposits on turbine blades.

When you add the proven advantages of C-E Turbo-Separators to the operating characteristics of modern designs of C-E Utility Boilers, you have the right combination for top year-around plant performance on all counts — efficiency, capacity and continuity of service.

6-758

COMBUSTION ENGINEERING

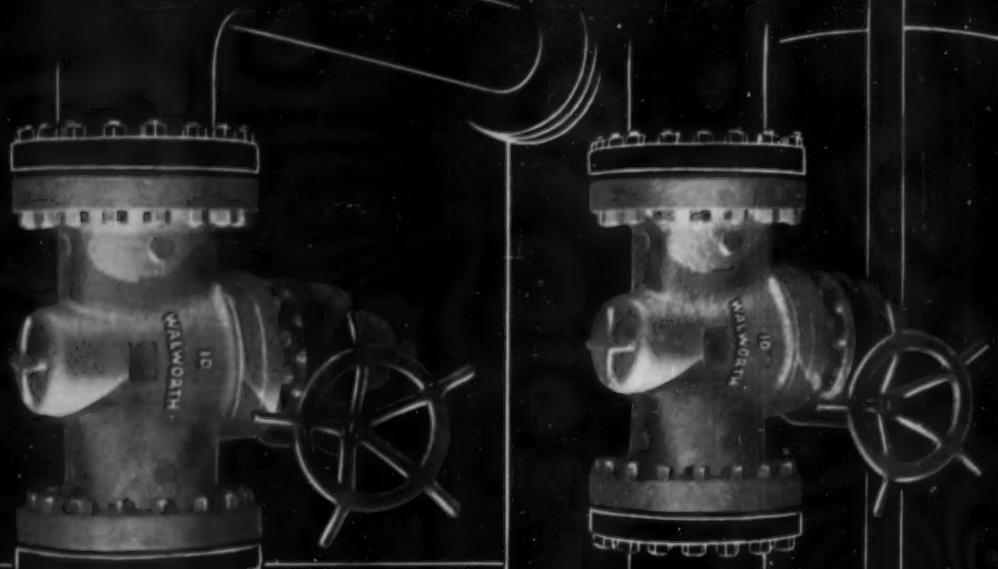
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BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS, AUTOMATIC WATER HEATERS, SOIL PIPE

WALWORTH



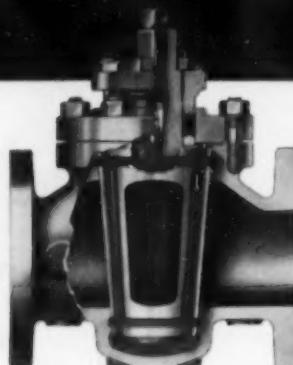
LUBRICATED PLUG VALVES

Better because ... They are pressure sealed with an insoluble lubricant readily renewed while the valve is in service. Lubricant completely surrounds the plug ports assuring a tight seal against leaks. It also insures ease of operation by reducing friction between the body and the plug while at the same time protecting the finished surfaces against corrosion and wear.

Walworth Lubricated Plug Valves are the most satisfactory valves available for the handling of gritty suspensions, and many other destructive, erosive, and corrosive industrial and chemical solutions.

They are ideal for general refinery and pipeline service.

For full information see your Walworth Distributor, or write for your copy of Bulletin 111. Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.



Lubricant system of a Walworth No. 1700F Regular Gland, Wrench Operated, Steel-Iron, Lubricated Plug Valve. Other Walworth Lubricated Plug Valves include Single Gland, and Ball Bearing types. Sizes to 30-inches — pressures to 5,000 psi, and for vacuum service.

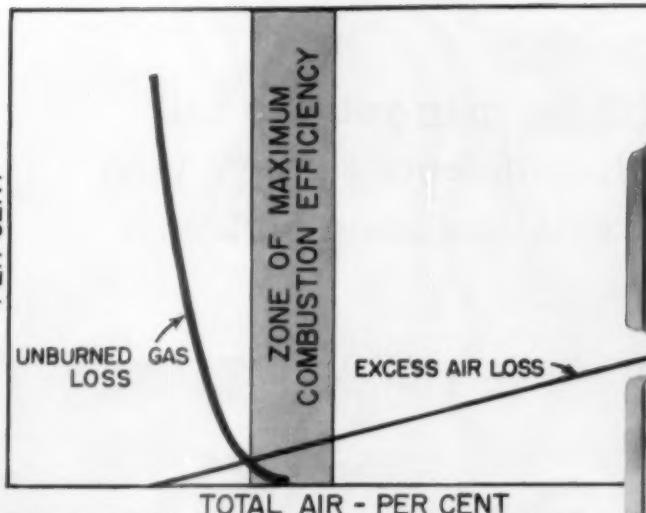
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DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

HEAT LOST IN FLUE GASES
PER CENT



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.



BAILEY announces . . . New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. **Excess air**—regardless of the fuel or combinations of fuels being burned.
2. **The mixing efficiency of your fuel-burning equipment**—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a single fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced—until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off

sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. PDI-1



BAILEY METER COMPANY

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**Meet the man you can call
with confidence to solve your
thermal insulation problems**



To insulate outdoor tanks with complete weather protection, these skilled J-M applicators follow a specification developed by Johns-Manville. Here they are fastening J-M Asbestocite® Sheets over J-M Zerolite® Insulation. J-M 85% Magnesia Insulation is also widely used for this type of equipment.

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lation Contractor can select the right insulation for the most dependable service on your job. To develop new and improved insulation materials Johns-Manville maintains the J-M Research Center—largest laboratory of its kind in the world.

2. You get dependable engineering—For 95 years Johns-Manville has been accumulating insulation engineering experience. J-M Insulation Engineers are called upon to solve insulation problems of every type and magnitude, in every industry. Since your J-M Insulation Contractor works closely with J-M Insulation Engineers, he brings to every job a high degree of

training, skill and experience.

3. You get dependable application—Johns-Manville has set up a nationwide organization of J-M Insulation Contractors to serve you. These Contractors maintain staffs of insulation engineers as well as skilled mechanics thoroughly trained in J-M's proved application methods. You can have absolute confidence in their ability to apply J-M insulations correctly for trouble-free performance.

For further information and the name of your J-M Insulation Contractor, write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

*Reg. U. S. Pat. Off.



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If you are not already getting the security from water treatment troubles that regular calls from your Nalco Representative bring, call or write today for prompt action.

Nalco WATER TECHS

A paper on "A Laboratory Method for the Study of Steam Condensate Corrosion Inhibitors," presented at the 8th Annual Conference, National Association of Corrosion Engineers, has been reprinted by Nalco for distribution to men interested in this problem. Your copy will be sent free upon request.

NATIONAL ALUMINATE CORPORATION

6234 West 66th Place • Chicago 38, Illinois
In Canada: Alchem Limited, Burlington, Ontario

THE
Nalco

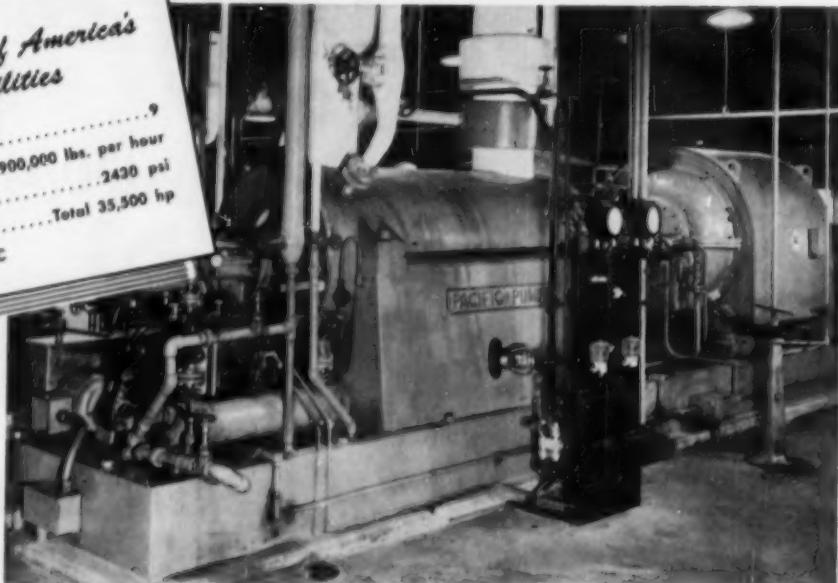
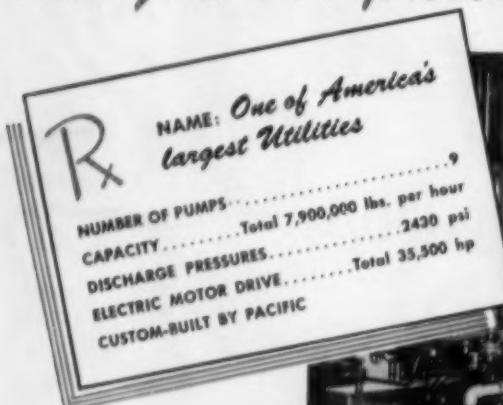
SYSTEM . . . Serving Industry through Practical Applied Science

Pacific

**BOILER FEED
PUMPS**

are Custom-Built
to your specifications

Write your own "prescription":



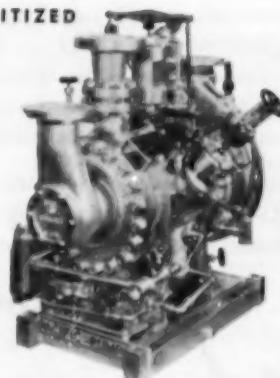
Pacific Boiler Feed Pumps are fabricated from selected materials to provide the utmost structural strength and stability — maximum resistance to corrosion-erosion and wear. Built in multi-stages for capacities to 2700 gpm; discharge pressures to 3000 psig; speeds to 5000 rpm.

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steady dependable output!*

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Discharge Pressures to 1100 psi
Steam to 900 psi—850°F. TT
Exhaust Pressures to 50 psi
Speeds to 10,000 rpm

Write for bulletins 109 and 118



PACIFIC
Precision, Built
PUMPS

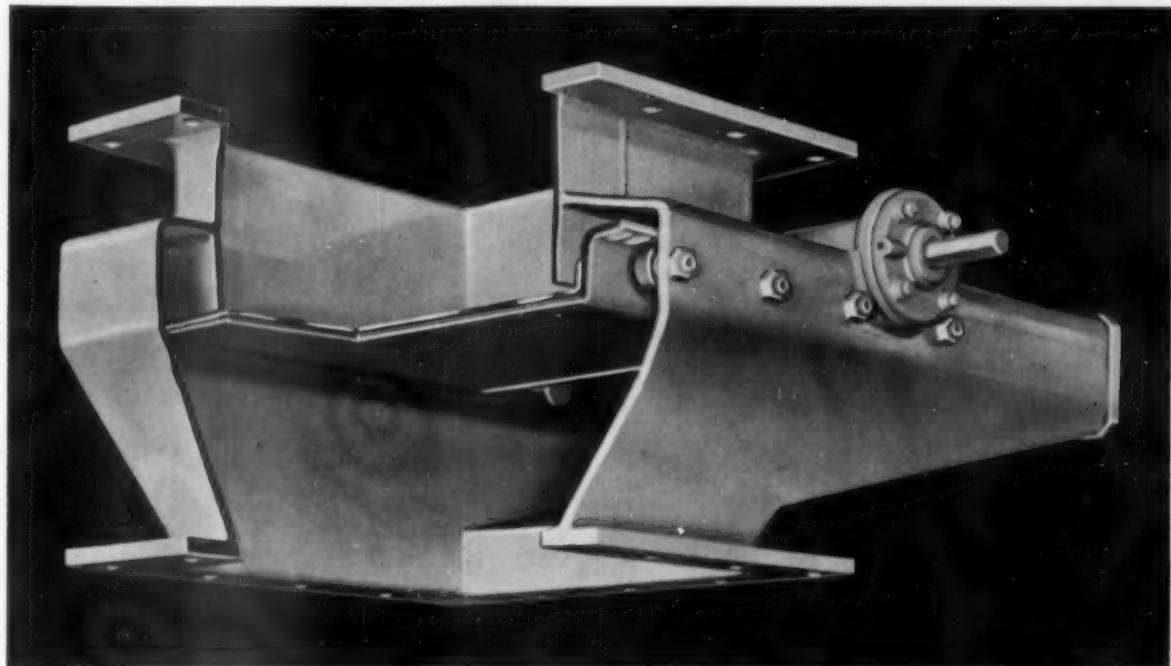
Pacific Pumps inc.

HUNTINGTON PARK, CALIFORNIA

Export Office: Chanin Bldg., 122 E. 42nd St., New York • Offices in All Principal Cities

8

January 1955—COMBUSTION



Here's The Inside Story On The New **S-E-CO. Coal Valve**

Strip the $\frac{3}{8}$ " steel skin off our new coal valve and you'll quickly see why *you get more when you buy S-E-Co.*

First, notice the deep U-shaped gate which completely shields rollers, racks and pinions from coal flow. See how the gate provides lap closure on all four sides assuring positive cut-off. Also, note the stainless steel liner on top side of the gate to combat corrosion.

Carefully formed ladder racks, for their part, are self-cleaning having no root portion in which coal dust can build up and cause jamming. The multi-faced pinions, located above the racks, are also of self-cleaning design. Consequently, the gate moves smoothly with little effort, even after long periods of not being operated.

Notice the clean interior design. Slopes have been kept at a maximum with shoulders and projections eliminated. Even the poke hole covers fit flush with the inside of the valve body so that nothing interferes with flow of coal through the valve.

For a complete list of all the outstanding features of the new S-E-Co. Coal Valve together with installation photographs and dimensions, write for Bulletin No. 97.



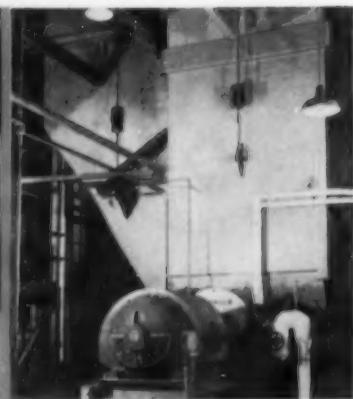
STOCK Equipment Company
745-C, HANNA BLDG., CLEVELAND 15, OHIO



Base for supporting refinery tower, provided with Grinnell Spring Hangers for flexible support.



Grinnell Spring Hangers on large vessel of catalytic cracking unit in oil refinery.



Induced draft duct and blower in power station. Operates at about 500°F. Supported by Grinnell Spring Hangers.

**To support loads
that won't stand still . . .**

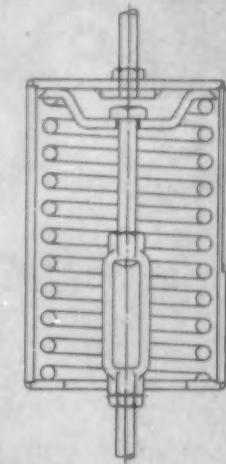
GRINNELL PRE-ENGINEERED SPRING HANGERS

There are many industrial installations where heavy loads must be firmly, but flexibly, supported to keep them under control. Thermal expansion and contraction, of course, can move ponderous objects many inches. Shock and vibration, too, can make rigid support of heavy loads hazardous, due to possible serious trouble at terminals.

For installations such as these, more and more engineers are turning to *flexible* supports by Grinnell. Grinnell Variable Spring Hangers are *pre-engineered* to minimize changes in supporting force over total range of movement. Here are the important features that let these units turn in a star performance in a supporting role:

- Maximum variation in supporting force per $\frac{1}{2}$ " of deflection is 10½% of rated capacity — in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- Solid steel casing protects spring from damage and weather. Guides assure
- continuous alignment and concentric loading of spring.
- 18 sizes available from stock — load ranges from 53 lbs. to 12,000 lbs.
- Easy selection of proper sizes from simple capacity table.
- Installation is simplified by integral load scale and travel indicators.

*Precompression is a patented feature.



VARIABLE SPRING HANGER

FIG. B-268

Fig. B-268, Type A, is designed for attachment to its supporting member by screwing a rod into a bushing in the top cap of the hanger. Adjustment of the hanger load is accomplished by turning the turnbuckle on the lower hanger rod until the hanger picks up the load and the load indicator points to the desired position. Six other types of attachment are available.

Grinnell Variable Spring Hangers are also available in half sizes (Fig. B-82); and in double spring sizes (Fig. B-98).

GRINNELL
AMERICA'S #1 SUPPLIER OF
PIPE HANGERS AND SUPPORTS



Grinnell Company, Inc., Providence, Rhode Island

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermalier unit heaters • valves
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FOR SPACE HEATING

Many varieties of non clinkering coals ideal for stoker use and hand firing

*Always ready
to serve you...*



with a coal that's exactly right

Name your choice—in "Bituminousland" along the Baltimore & Ohio, we have it! Here Nature has stored a supply of economical heat and energy sufficient to last for centuries.

B&O Bituminous coals exist in wide variety. The mines that produce them are thoroughly mechanized so that costs are kept low, size and quality uniform. Nearness to industrial centers results in low transportation costs, and the ease of storing removes the need for expensive facilities. Furthermore, new methods and equipment have increased the burning value of Bituminous.

ASK OUR MAN! Let him direct you to the best coal for your needs, and explain proper firing methods. You'll be more than pleased at the improved efficiency, economy, and cleanliness of B&O Bituminous.



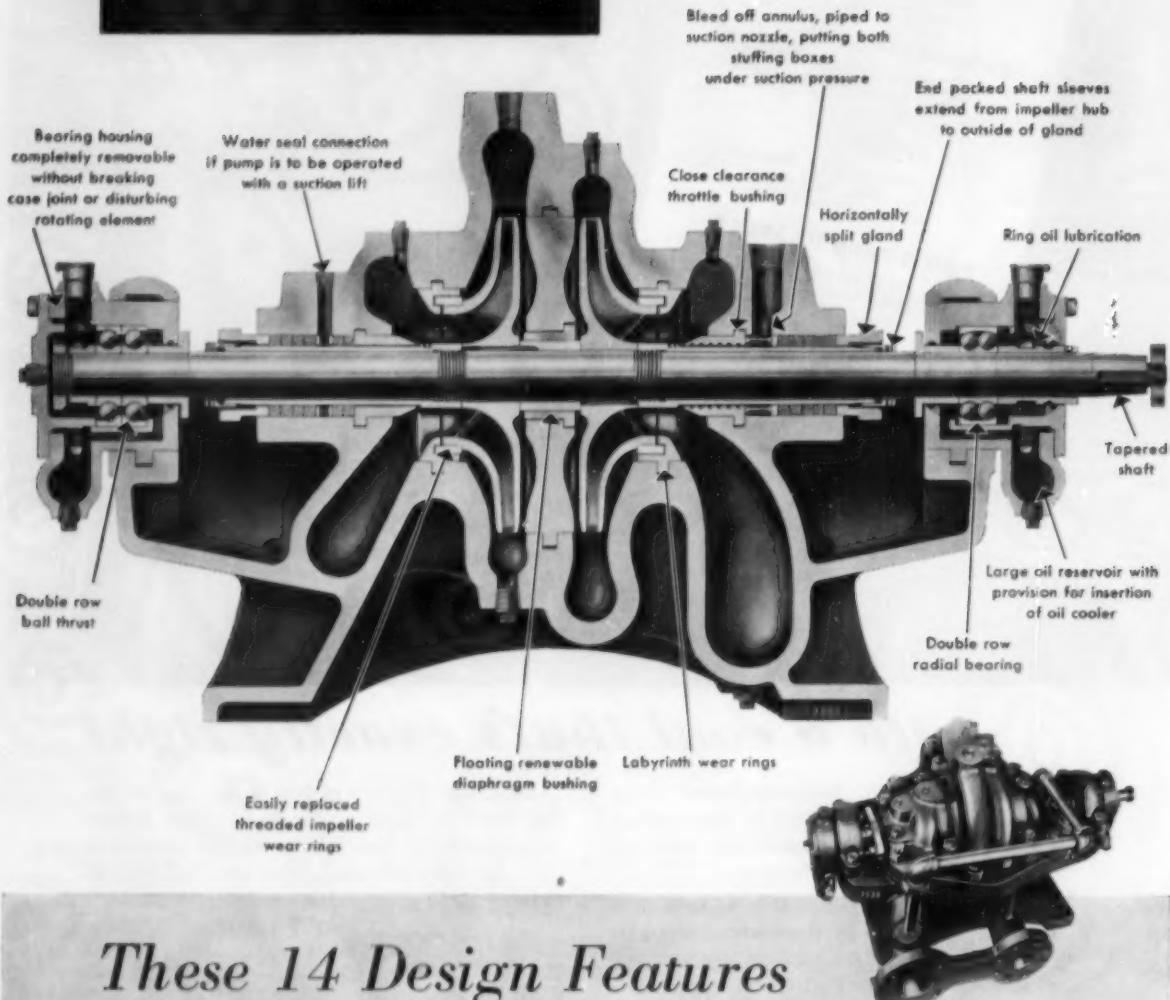
**BITUMINOUS COALS
FOR EVERY PURPOSE**



BALTIMORE & OHIO RAILROAD

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DE LAVAL
TWO-STAGE
HORIZONTAL PUMPS



*These 14 Design Features
Insure Long-range, Low-cost Service*

Look at the important design features highlighted in this cross-section. You will clearly see why De Laval 21S-2KS Two-Stage Horizontal Pumps are designed to give you long, dependable, highly efficient service. • These

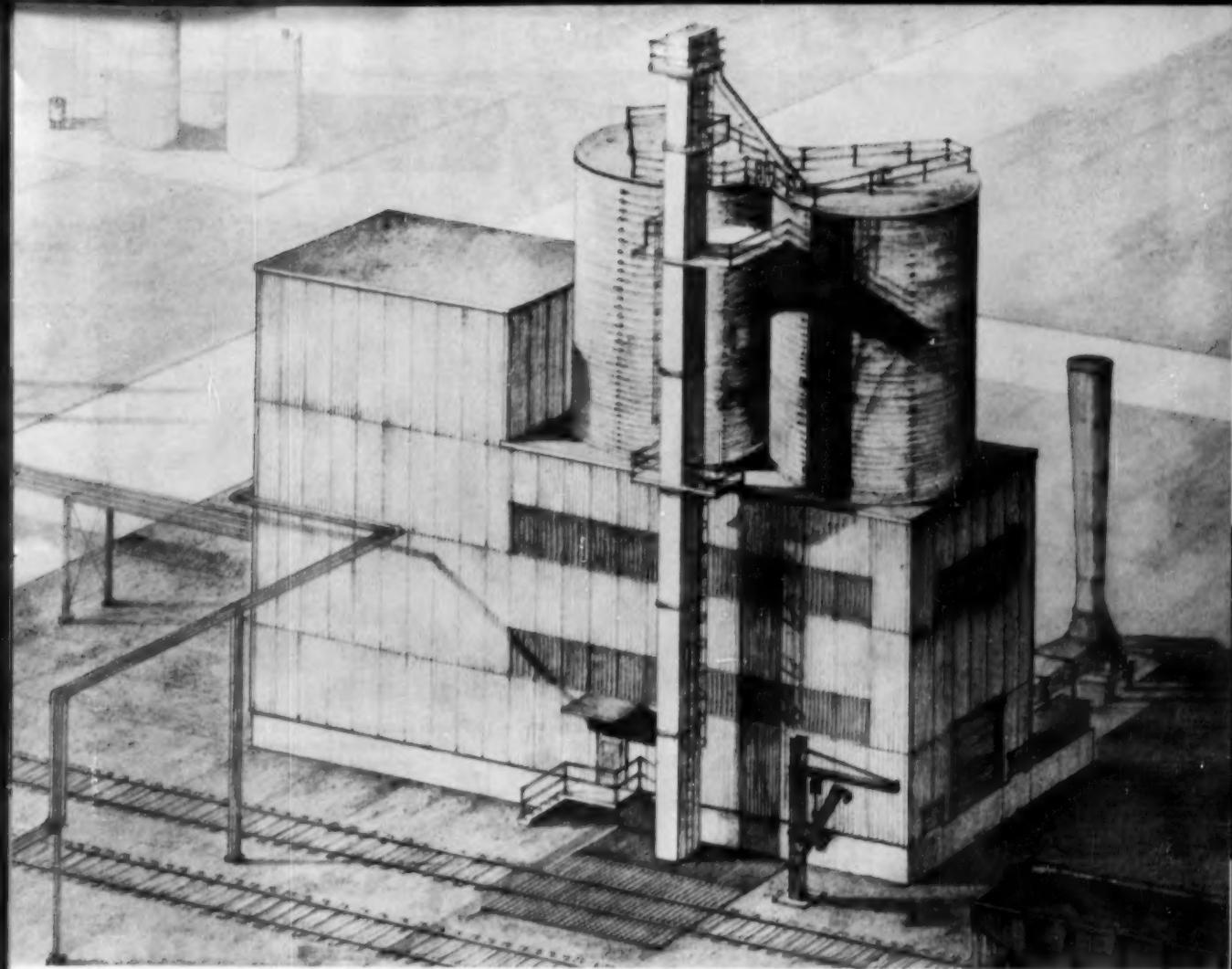
pumps are precision-made to quality manufacturing standards. They are available in capacities from 75 to 3,000 gpm, sizes from 2" to 8" discharge and heads to 750 feet. Write for Bulletin 1501 giving complete data.



DE LAVAL Centrifugal Pumps

DE LAVAL STEAM TURBINE COMPANY

886 Nottingham Way, Trenton 2, New Jersey



Stauffer Chemical's New Petrochemical Plant Burns Coal the Modern Way

When Stauffer Chemical Co. constructed a multi-million dollar Petrochemical plant in Louisville, Kentucky, the Process Engineering firm of Singmaster & Breyer specified and built a modern coal burning boiler plant (shown above)—incorporating a fully automatic combustion system, completely up-to-date coal and ash handling equipment.

The results? Fuel and labor costs are at a minimum. Dust concentration is well within the limit fixed by the Louisville Air Pollution Control Commission. Initial cost of the plant was \$6.38 per pound of steam per hour, compared to an average \$8 to \$10 for plants the same size. And total cost of steam—including fuel, labor, maintenance, power, and fixed costs—is only 60¢ per 1000 pounds!

Investigate Your Fuel Costs

If you're planning to modernize your plant or build a new one—or if you are just interested in cutting fuel costs—find out how coal, burned the modern way, compares to other fuels. Talk to a consulting engineer

or your nearest coal distributor. Their advice may save you thousands of dollars each year.

facts you should know about coal

In most industrial areas, bituminous coal is the lowest-cost fuel available.

Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar.

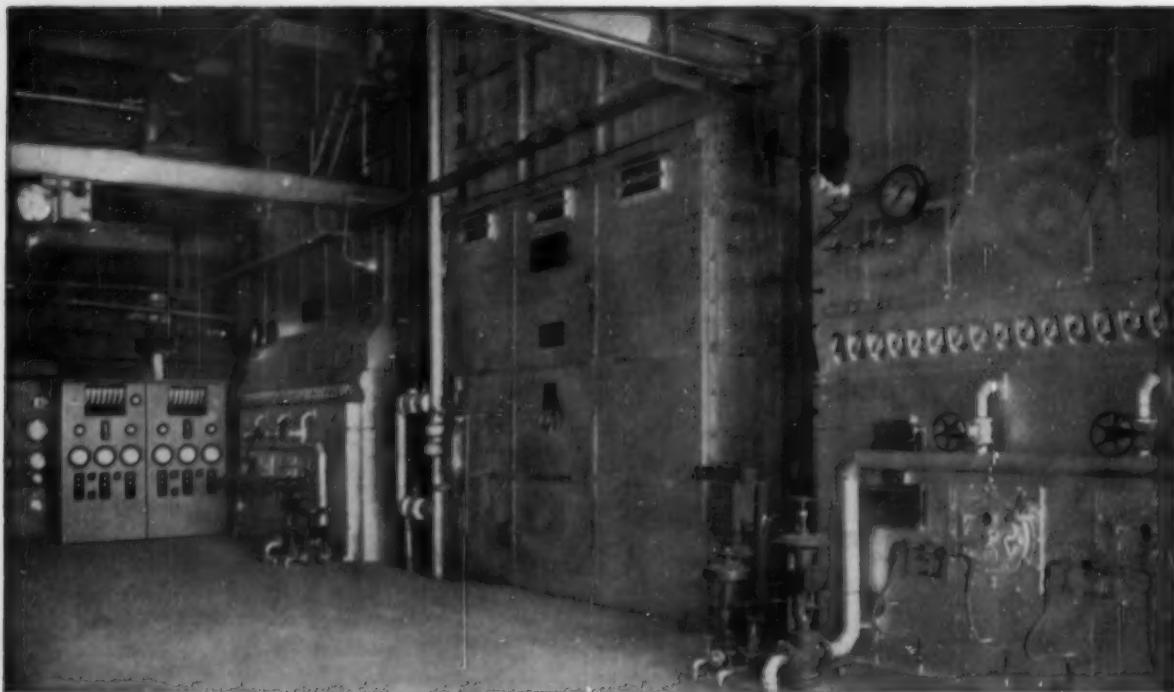
Automatic coal and ash handling systems can cut your labor cost to a minimum.

Coal is the safest fuel to store and use. No dust or smoke problems when coal is burned with modern equipment.

Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

BITUMINOUS COAL INSTITUTE
A Department of National Coal Association
Southern Building, Washington 5, D.C.



Boiler room at Kansas State College. Republic instrument panel is at left. Boilers are arranged for either gas or oil firing.

REPUBLIC

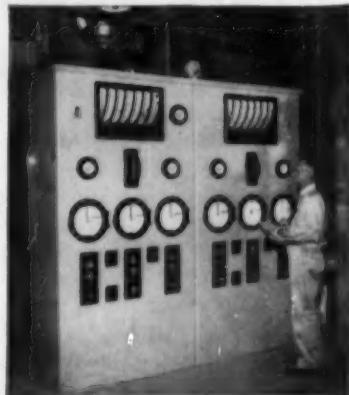
Automatic COMBUSTION CONTROLS

Go to College to Cut Steam Costs

At Kansas State College, a complete Republic combustion control system, feedwater level controls and instruments automatically operate two 50,000 pounds per hour boilers for maximum combustion efficiency. Fired by either oil or gas, these boilers generate steam at 225 psig and 500°F.

With Republic automatic combustion controls in this power plant, all loads, including "peaks", are met smoothly with steam output exactly matched to demand. Fuel costs per pound of steam produced are kept at a minimum 24 hours a day, seven days a week. Maintenance costs are kept low, too, by continuous proper operation of the boilers.

Whatever the size of your boiler, its draft arrangement, type or types of fuel to be fired and load conditions to be met, there's a Republic combustion control system that can bring these advantages to you. Our engineering staff, with more than 37 years *specialized* experience in combustion control systems, is at your service to help you get the system that exactly meets your needs. For your convenience, there's a nearby Republic field engineer to bring you all the facts. Write and make a date to see him soon.



Instruments on the control panel monitor boiler operation. If desired, the entire combustion system can be operated manually from this panel.

REPUBLIC FLOW METERS CO. • 2240 DIVERSEY PARKWAY • CHICAGO 47, ILLINOIS



Bartlett-Snow coal handling at Green River

● The illustration above shows the first 60,000 KW unit of a plant that is to be enlarged into a 180,000 KW station. The coal handling equipment which was built, and installed, by us to Sargent & Lundy specifications, includes track hopper; duplex feeder; belt conveyors of 300 ton capacity; surge hopper for the storing out conveyor; crusher, weightometer, and sampling; inexpensive open galleries with hinged covers to protect the belt from the weather; and our newest design of motorized travelling tripper equipped to insure dust-free operation. For maximum efficiency and fixed unit responsibility, let the Bartlett-Snow coal handling engineers handle your next job.



"Builders of Equipment for People You Know"

General View of Green River Power Station
Kentucky Utilities Company
Sargent & Lundy
Consulting Engineers

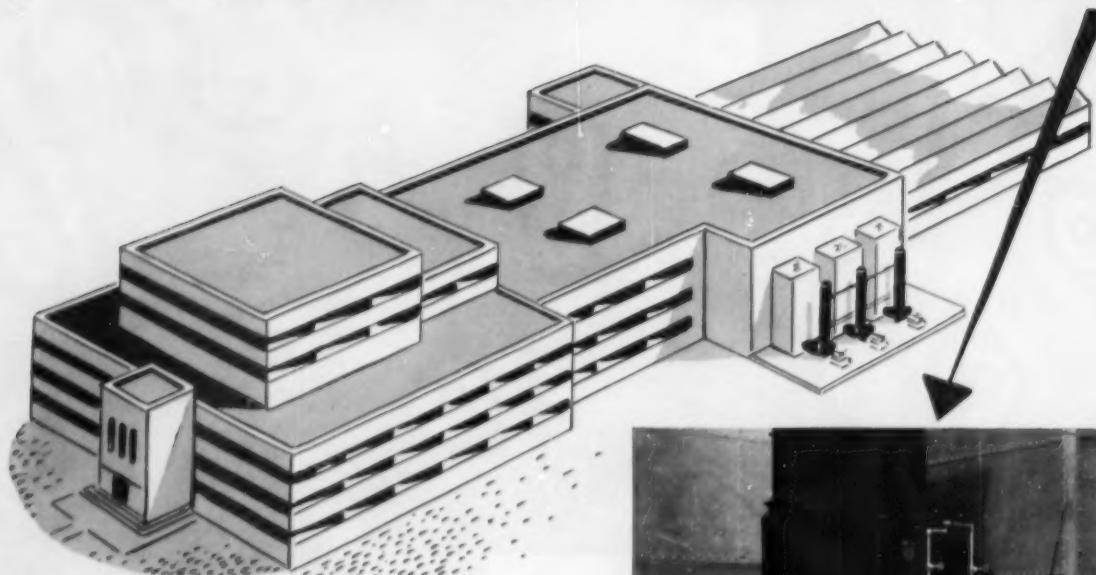


Discharge Chutes of this Bartlett-Snow Motorized Travelling Tripper are Fitted with Plows and Rollers that Open and Replace the Bunker Seal Assuring Dust-Free Operation



View of Open Belt Conveyor Gallery. Protecting Hoods are Hinged on One Side and can be Latched in Either Open or Closed Position

WHERE AN ENTIRE PLANT DEPENDS ON THESE FANS



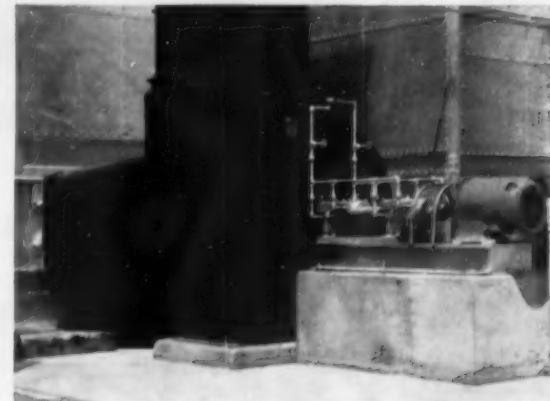
BE SURE THEY'RE

"Buffalo"

THE DRAFT FANS
WITH THE "Q" FACTOR*

The draft fan literally supplies the "breath of life" to the plant . . . or, in the case of utility stations, to entire communities. It's an understatement to say that draft-fan timeouts are costly, and that the most durable and easily serviced fan is the most economical one.

This is why "Buffalo" Draft Fans are saving money in so many installations. They're husky . . . built up in the places where it counts. Rotor



"Buffalo" Induced Draft Fan in outdoor installation

blades, rotor plates and housings are extra heavy and rigid.

Bearings and shafts are oversize. In "Buffalo" Induced Draft Fans, removable scroll liners and replaceable welded-on wearing strips protect housings and blades. Small wonder that many "Buffalo" Draft Fans are still going strong after many years on the job.

Write for Bulletin 3750 and see why "Buffalo" is your safest choice for the vital draft job.

**The "Q" Factor — the built-in Quality
which provides trouble-free satisfaction and long life.*



BUFFALO FORGE COMPANY

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BUFFALO, N.Y.

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which
impulse
for you?



STANDARD

The standard YARWAY Impulse Steam Trap serves all normal trapping requirements. Factory set to operate without adjustment at all pressures from 20 psi to 400 psi (Series 60) and 600 psi (Series 120). For pressures below 20 psi, merely remove split washer.

Numerous advantages like:

- small size
- quick heating
- steady temperatures
- stainless steel construction
- one moving part
- non-freezing
- low cost

More than 900,000 used throughout industry.

Write for YARWAY Bulletin T-1740.

HIGH PRESSURE, INTEGRAL STRAINER

YARWAY Integral Strainer High Pressure Impulse Steam Traps operate on some of the highest pressure steam lines in the country. Same operating principle as the standard YARWAY Impulse Trap. Strainer built into trap.

Ample capacity when system is being "warmed up"—yet will handle relatively small amounts of high temperature condensate without losing prime. Six sizes— $\frac{1}{2}$ " to 2". Pressures to 1500 psi (flanged ends) or 2500 psi (welding ends).

Write for YARWAY Bulletin T-1740.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY

impulse steam traps

YARWAY Impulse Steam Traps and Fine Screen Strainers are stocked and sold by more than 250 convenient local distributors. Write for name of one nearest you.

for the man considering a PACKAGE BOILER

**new all-electric
METERING TYPE
PACKAGED CONTROL
by HAYS**



Now available for *all* makes and sizes of water tube type package boilers is the new all-electric, metering type Hays packaged control.

Metering type control provides maximum combustion efficiency regardless of the fuel burned because it *actually meters* the fuel flow and air flow, and automatically maintains the desired ratio. No adjustments are needed when changing fuels or oil burner tips.

All-electric operation includes not only safety devices but also steam, fuel, and air controllers and valves—uses only the normal source of AC voltage. No compressed air is required.

Fully automatic, safe and reliable operation is assured because Hays maintains the same industrial quality built into the largest utility combustion control system and it is factory tested before shipment.

Complete package in one simple and inexpensive to install panel board.

Write today for fact-filled Bulletin 53-1088-239.

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Automatic Combustion Control • Veriflow Meters and
Veritrol • Electronic Oxygen Recorders • CO₂ Recorders
Boiler Panels • Gas Analyzers • Combustion Test Sets
Draft Gages • Electronic Flowmeters • Miniature
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... THE COMPLETE QUALITY LINE ... POWELL VALVES ... THE COMPLETE QUALITY LINE ...

POWELL VALVES ... THE COMPLETE QUALITY LINE ... POWELL VALVES

POWELL VALVES FOR POWER PLANTS



FIG. 375—Bronze
Gate Valve For
200 Pounds W.S.P.



FIG. 19003—900-Pound
Pressure Seal Gate Valve

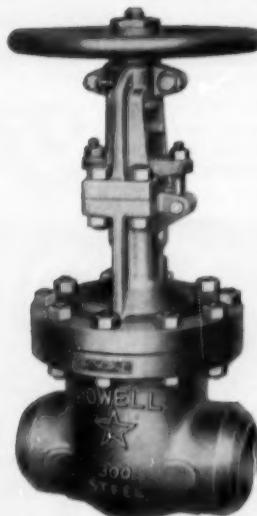


FIG. 1793—Iron Body Bronze
Mounted Gate Valve For
125 Pounds W.P.

FIG. 3003—Steel Gate Valve
For 300 Pounds W.S.P.

POWELL VALVES ... THE COMPLETE QUALITY LINE ... POWELL VALVES

Just name the valve you need for your power plant—Powell can supply it. And you can be certain that every Powell Valve will give you *dependable* flow control.

Shown above are just a few Powell Valves for power plants. Investigate the *complete* line of quality valves that have a proven record of long life and dependable service.

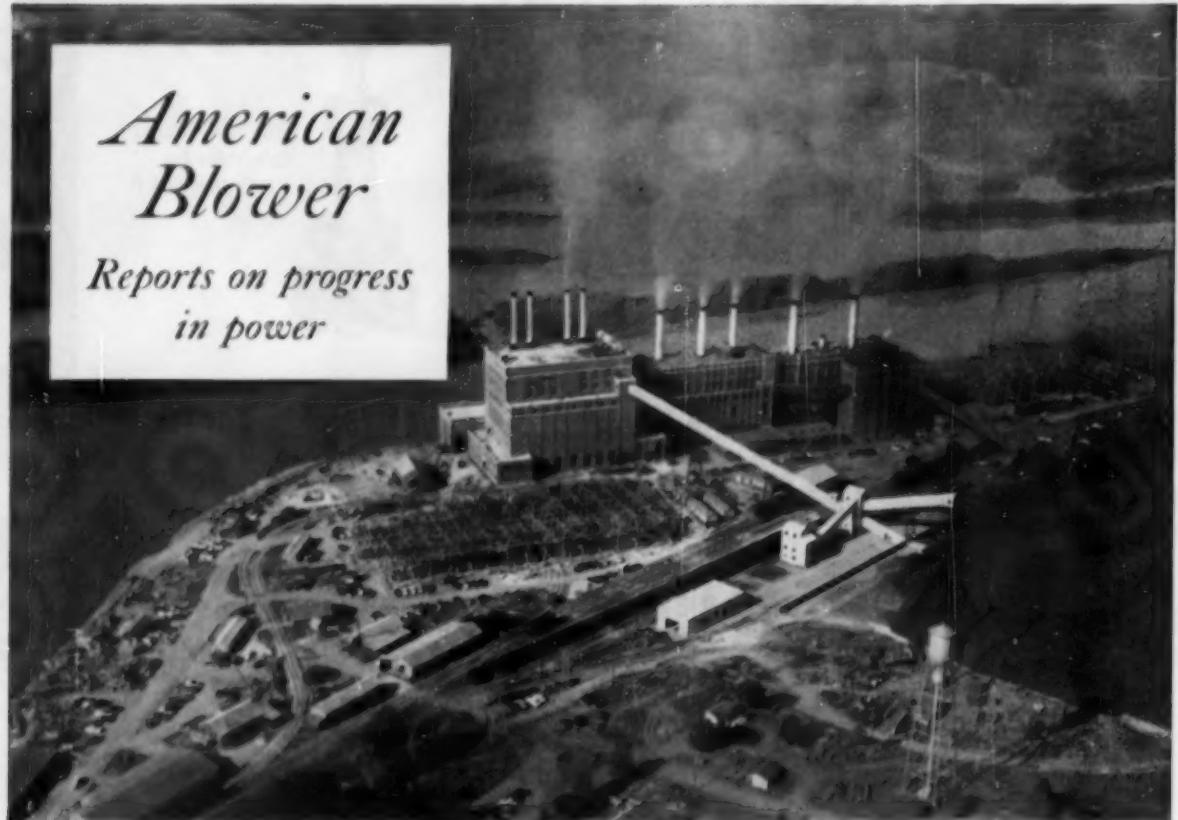
Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have. Write . . .

The Wm. Powell Company,
Cincinnati 22, Ohio..... 109TH year

From a tiny trickle to a mighty

American Blower

*Reports on progress
in power*

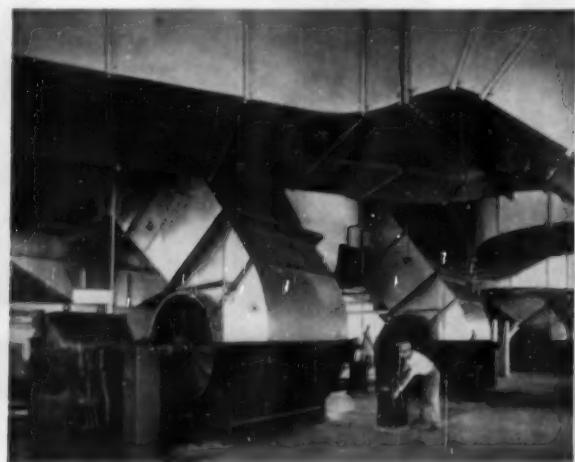


1. Duke Power's Buck Plant (above) near Salisbury, N.C., increased capacity by 250,000 kw in 1953. Two new generating units, recently completed, also added 266,000 kw to the Riverbend Plant near Charlotte, N.C.

At the Dan River Plant near Draper, N.C., a new 150,000 kw unit is under construction, to be completed in 1955. Two other Duke Power plants are: Cliffside near Shelby, N.C. and Lee near Greenville, S.C.

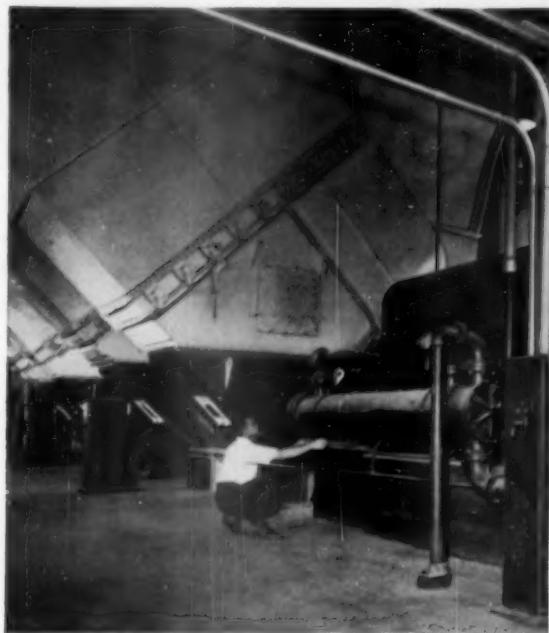


2. American Blower Gyrol Fluid Drive—type VS, class 6—provides smooth, adjustable speed control of a boiler feed pump. It is coupled with a 1750 hp motor in the Buck Plant.

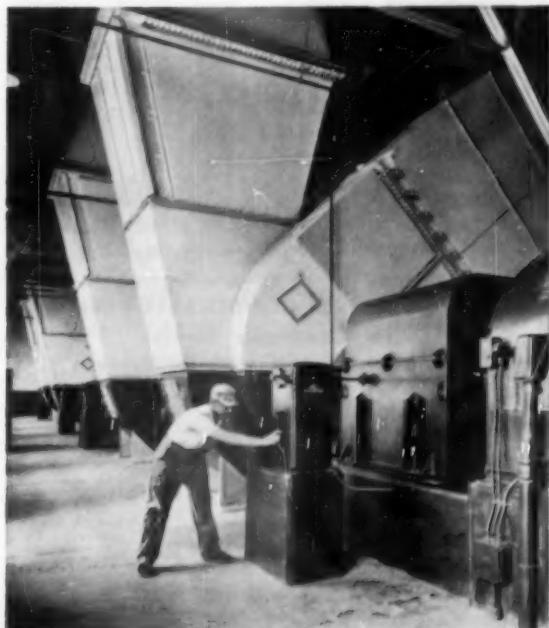


3. Four American Blower Forced Draft Fans are installed in Duke Power's Riverbend Plant. Each has a capacity of 143,000 cfm @ 100°F @ 1180 rpm @ 406 bhp.

2,211,000 kw—that's Duke Power!



4. Duke Power installed these four American Blower Induced Draft Fans at the Buck Plant. Each is driven through a type VS, class 4 American Blower Gýrol Fluid Drive.



5. Rated @ 234,000 cfm @ 296°F @ 637 bhp, each of these four American Blower Induced Draft Fans at the Riverbend Plant is coupled with an American Blower Gýrol Fluid Drive.

In its tremendous expansion, another leading power company chooses American Blower equipment

On April 1, 1904, a power line from a small hydroelectric plant at India Hook Shoals, S.C., was completed to Rock Hill, S.C. This was the simple beginning of the Duke Power Company system . . . a system that today serves over half a million customers in a 20,000-square-mile area in the Piedmont Carolinas — supplying electricity for some 35% of the nation's textile spindles . . . a system that through continued expansion will have an estimated capacity of 2,211,000 kw in 1955!

Planning far ahead of customers' needs is basic to this progressive, investor-owned utility. During the eight years from 1946 through 1953, Duke Power spent \$231,000,000 to expand facilities, including \$6,000,000 for the South's first steel-tower 230 kw line. Present plans call for additional expenditures, through 1964, of \$30,000,000 annually. Duke Power is surging ahead with a dramatic fifty years of generating electricity behind them!

Supplying dependable air handling equipment and Gýrol Fluid Drives is the important part American Blower plays in Duke Power's tremendous expansion. (See pictures and captions.) It's a big role, one that is being duplicated in leading power and industrial plants everywhere.

If your future calls for expansion or modernization, talk over your plans and problems with an experienced American Blower representative. He can recommend efficient, economical equipment—including Mechanical Draft Fans, Fly Ash Precipitators, Dust Collectors, Heavy Duty Steam Coils and Gýrol Fluid Drives for boiler feed pump and fan control. Call your nearest American Blower Branch Office.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN

CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American Radiator & Standard Sanitary Corporation

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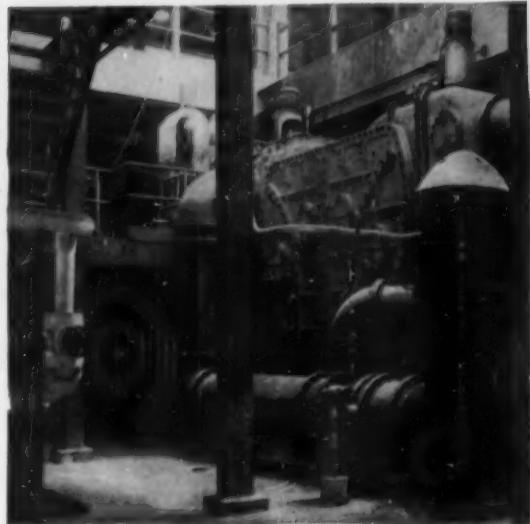
NOTES

for the engineer's note book

NO SHUTDOWN, NO LOAD REDUCTION, NO HAND CLEANING . . . WITH C. H. WHEELER REVERSE FLOW CONDENSERS

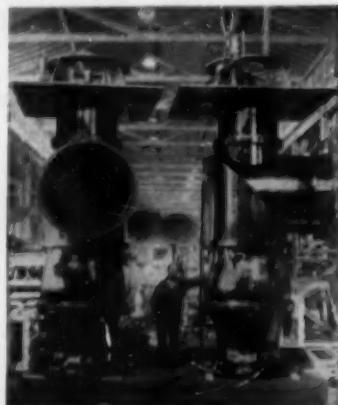
The savings in dollars and downtime effected by C. H. Wheeler's Reverse Flow design for steam condensers are a matter of record in public utilities and private power plants throughout the country. Chances are, you can inspect a nearby installation and learn first hand how efficiently debris of vegetable, animal and mineral matter is dislodged from the tube sheet and flushed away by reversing the flow of the cooling water through the Condenser. Cleaning work that formerly took hours is accomplished in minutes with no interruption in load. C. H. Wheeler custom-engineers your steam condensing hook-up to pay off in long range sustained efficiency. (Bulletins mailed on request.)

... ON C. H. WHEELER POWER PLANT EQUIPMENT



C. H. WHEELER CIRCULATORS *Lasting Dependability Minimum Maintenance*

C. H. Wheeler Circulators include: mix-flow vertical wet pit type with both standard and pull-out design; vertical mix-flow volute type for dry pit installations; and horizontal single stage centrifugal constructions to 100,000 GPM capacities. C. H. Wheeler pumps for general service include: single stage high head double suction; multi-stage with horizontal or vertical split case; pumps for sump,



process and fire protection services. C. H. Wheeler also invites your special problems requiring custom design. (Bulletins mailed on request.)

TUBEJET AIR EJECTORS *Steel Shell More Reliable*

C. H. Wheeler Steel Shell Tubejet Air Ejectors provide worthwhile savings in space and weight. They are available with either single or multiple element, two-stage type with combined surface inter-after condenser. Write for Bulletin.



C. H. WHEELER CONDENSATE PUMPS *for Condenser Service with Turbine and Motor Drive Write for Bulletins*

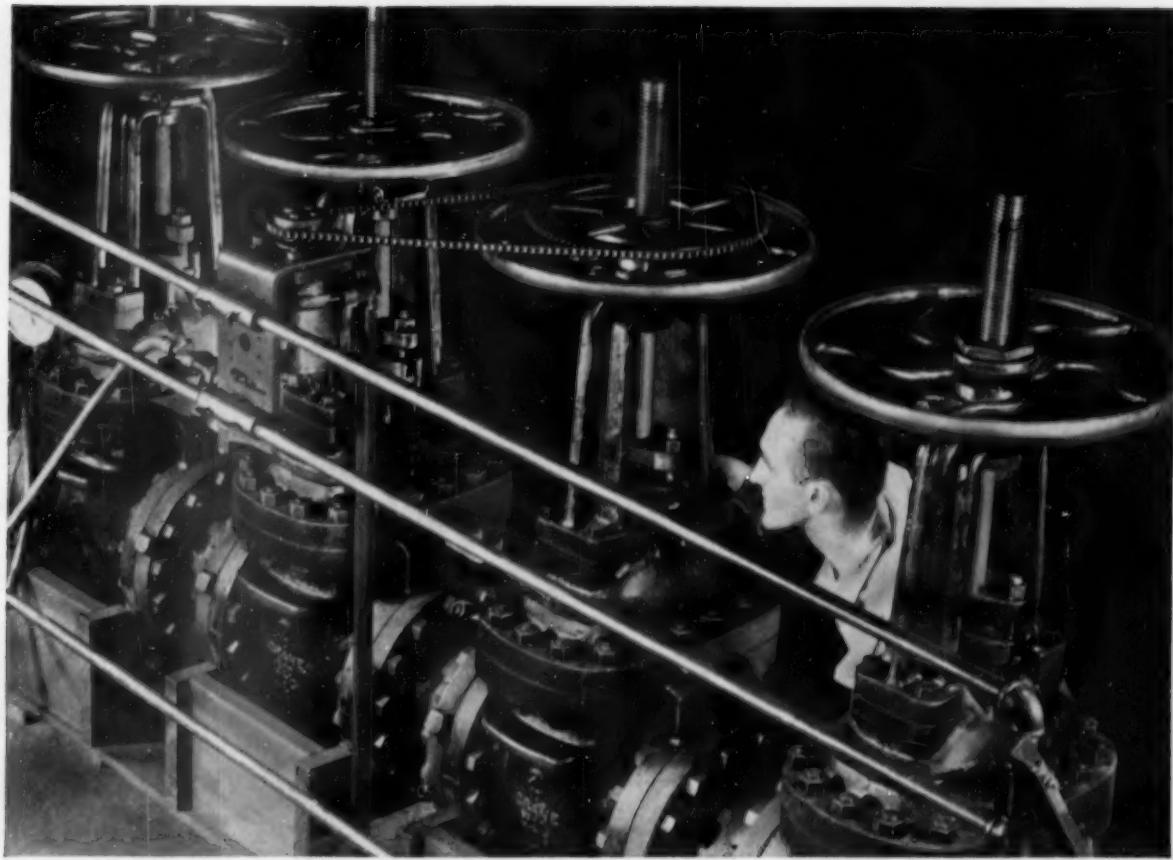


WE-400

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C. H. WHEELER MANUFACTURING CO., 19th & LEHIGH, PHILADELPHIA 32, PENNA.

Steam Condensers • Centrifugal, Axial and Mixed Flow Pumps • Steam Jet Ejectors • Vacuum Refrigeration
High Vacuum Process Equipment • Micro-Particle Reduction Mills • Marine Condensers and Ejectors • Deck Machinery.



Testing...testing...50 years and longer to make CRANE VALVES maintenance free

Testing for product performance values is an old custom with Crane. It was started long before many standards existed—long before others in the field used this means of product improvement and quality control.

Today's Crane valve testing is done in both field and laboratory by the most scientific techniques. This continuing work seeks to increase valve performance and lessen maintenance needs. A single example is the stem packing test shown above.

Here's one of the reasons back of the thrifty buyers' preference for Crane valves. They can rely on ever-improving Crane quality to protect their company's investments in piping equipment—especially today, in the face of high maintenance and repair costs. No wonder industry keeps using more Crane valves than any other make.

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Better Quality
Bigger Selection
in Valves
for Every Need



VULCAN

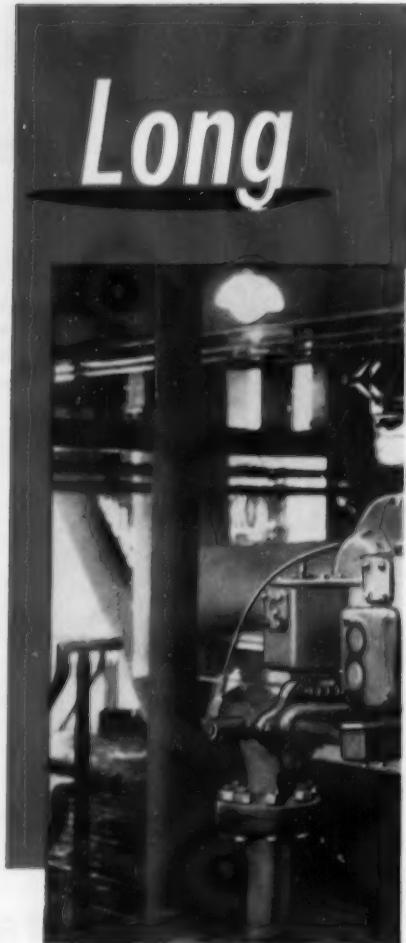
because of...

DUAL MOTORS DRIVE

Vulcan uses two motors. One extends and retracts the lance. The other rotates it. Motors may be air or electric. Speeds are independently adjustable.

JOETS AND LANCE DESIGN

Vulcan offers jets tailored to the job—straight bore or venturi; and angled to reach specific surfaces. Jets normally rotate while traversing, but may traverse only or oscillate through any angle. Lances from opposite sides of the furnace may fail to "meet" by as much as 12 feet, yet clean thoroughly.



CHOICE OF BLOWING MEDIUM

You can blow with any medium—air, steam or water, or any combination of them—without change of equipment.

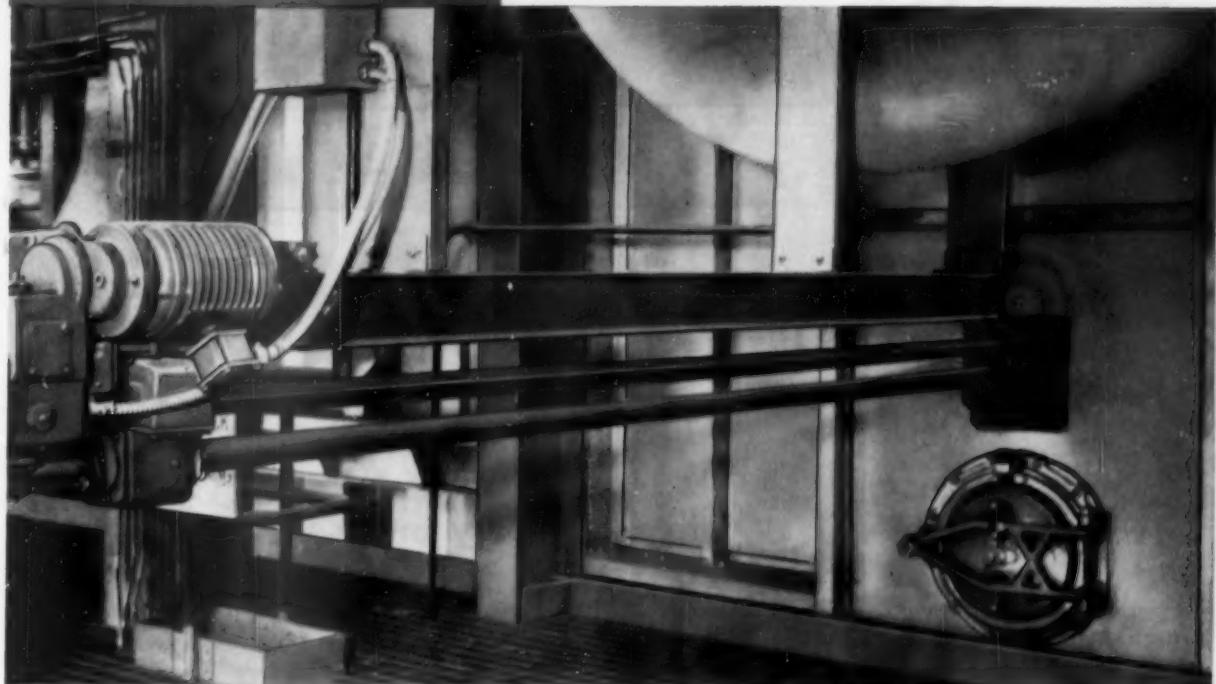
CHANGE OF SPEED

Two motors allow stop-and-go indexing with uniform rotation—or fast-and-slow change of pace. On "stop and go," the lance is stopped and rotated to clean the tubes—then sped across the open areas to the next row of tubes. On "fast and slow," the lance is slowed to clean the tubes, and sped while passing open areas. In each case, the result is a saving of blowing medium.

VULCAN Automatic

Retracts

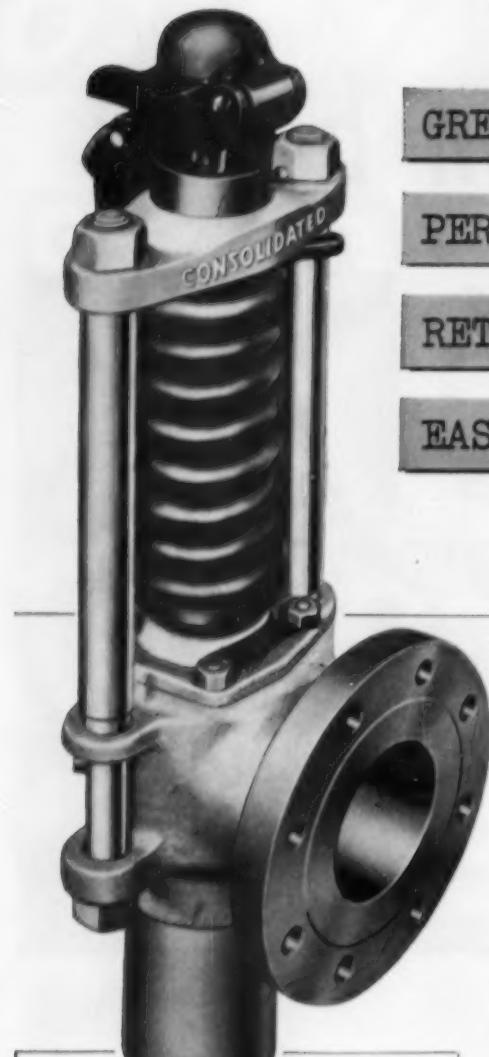
clean better



Vulcan Long Retracts clean better—with fewer outages, at lowest cost. They are engineered for optimum performance under varying conditions. They work equally well at any angle. They give you the benefit of dual-motor operation—one motor to traverse the lance, a second to rotate it. *Rotation is always in the same direction.* Repeated cleaning cycles result in an infinite number of double-helix paths that continually broaden the cleaning coverage. Lances can pass through as little as four inches of tube clearance. Write for Bulletin 1002.

COPES-VULCAN DIVISION
CONTINENTAL FOUNDRY & MACHINE COMPANY
ERIE 4, PENNSYLVANIA

 **Soot BLOWERS**



GREATER DISCHARGE CAPACITY...

PERMANENT TIGHTNESS...

RETAINED POPPING POINT...

EASILY CONTROLLED BLOWDOWN...

CONSOLIDATED
Maxiflow **SAFETY VALVE**

**sets a new standard
in safety and service**

Today's high-pressure, high-temperature steam generating plants require safety valves with greater discharge capacity. The Consolidated Maxiflow Safety Valve always has it available when needed.

Dependable tightness—month after month—is likewise inherent in the design of Maxiflow. Thermodisc seating equalizes temperature differentials when the valve reseats after blowing—thermal stresses are minimized, distortion is prevented.

Poping point retention is achieved by use of a special alloy steel to stabilize the spring support in the yoke rods—by use of a stainless steel spindle that provides thermal compensation for any elongation of other parts that affect spring loading.

Blowdown control, while the valve is under pressure, requires only a simple external adjustment.

Constant entrance conditions for steam flow are assured by precision-machined forged steel through bushing and inlet. No porous castings to leak.

These are but a few of the performance-proved features that make the Consolidated Maxiflow Safety Valve outstanding in safety and service. Five sizes— $1\frac{1}{2}$ ", 2", $2\frac{1}{2}$ ", 3", and 4"—make selection easy. Bulletin 707 contains full details, including capacity tables. Write for a copy.

Example of Discharge Capacity— $2\frac{1}{2}$ " Maxiflow	
Gauge Pressure PSI	Capacity Saturated Steam Pounds Per Hour A.S.M.E. Rating
1200	143,700
1500	179,000
2000	238,400
2500	297,600



CONSOLIDATED SAFETY VALVES



A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONN.

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, Stratford, Conn. 'CONSOLIDATED' SAFETY RELIEF VALVES, Tulsa, Okla. 'HANCOCK' VALVES, Watertown, Mass. AIRCRAFT CONTROL PRODUCTS, Danbury & Stratford, Conn. and Inglewood, Calif. 'SHAW-BOX' AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, Muskegon, Mich.

*Why your
Ljungstroms
are so efficient
—year
after year*



Air Preheater Corporation Field Engineers aim to visit every Ljungstrom Air Preheater in this country at least once a year. Their main objective is to increase availability and assure you a maximum return on your investment. They are always available for consultation.

This is just another reason why the Ljungstrom Air Preheater is *the most economical heating surface on the modern boiler*.

THE AIR PREHEATER CORPORATION

**60 East 42nd Street
New York 17, N. Y.**



Accurately Predicts Physical Reactions of HIGH PRESSURE, HIGH TEMPERATURE PIPING

Model testing makes practical the planning of high pressure, high temperature piping systems with advance knowledge of end reactions, stresses, and deflections encountered in actual operation.

The model illustrated exactly duplicates from an engineering standpoint — in miniature — double turbine piping installation being built by P.P. & E. for one of America's foremost utilities. Highly specialized testing apparatus accurately measures and directly indicates physical reactions at all points of this model under simulated operating temperature and pressure loads. These measure-

ments are projected to give precise information on the full size system.

On complex piping layouts model testing at Pittsburgh Piping is the only practical means to obtain a complete analysis. It eliminates the need for dependence on theoretical approximations, and minimizes the possibility of mathematical error. Data obtained from model testing enables construction of a full size system which is free from excessive stresses, reactions and movements which could damage joints, anchors and equipment connected to the pipe line.

Promoting Progress IN POWER AND PROCESS PIPING . . .

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PP-8



STAINLESS-CLAD STEEL DEFIES HANGUPS AND CORROSION WEAR

In September 1952, the Salem Harbor Station of the New England Electric System went on the line. Rated as one of the most efficient stations in the nation, it has had two years of trouble-free operation. Stainless-clad steel figures directly in the exceptional performance of the interior coal handling equipment. No hangups or maintenance problems have occurred.

At Salem Harbor, stainless-clad was used at every point of extreme wear. The corrosive and abrasive effects of wet coal were virtually eliminated at key points. Four bunker noses and feed pipes were made of $\frac{3}{8}$ " stainless-clad, hoppers used $\frac{1}{2}$ " and $\frac{3}{4}$ " clad, and chutes leading to the pulverizers are $\frac{1}{4}$ " clad.

Stainless-clad steel—a layer of solid stainless steel

Two boilers at Salem Harbor Station are fed by stainless-clad steel bunker noses and pipes. No hangups or repairs have been reported in two years of operation.

integrally and permanently bonded over its entire surface to a strong, low-cost carbon steel backing plate—was chosen here for its twofold economy: low initial cost and minimum maintenance. Its smooth surface defies hangups and, with hard use, develops a mirror-like finish. It can extend the service life of coal handling equipment through the useful life of the boiler.

If you would like detailed information, write for Bulletin 740. In addition, our Technical Service Department is available to work with your equipment builders and engineers in putting stainless-clad steel to work for you. If you would like the names of qualified equipment builders, write to the Manager, Marketing Service, 684 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.



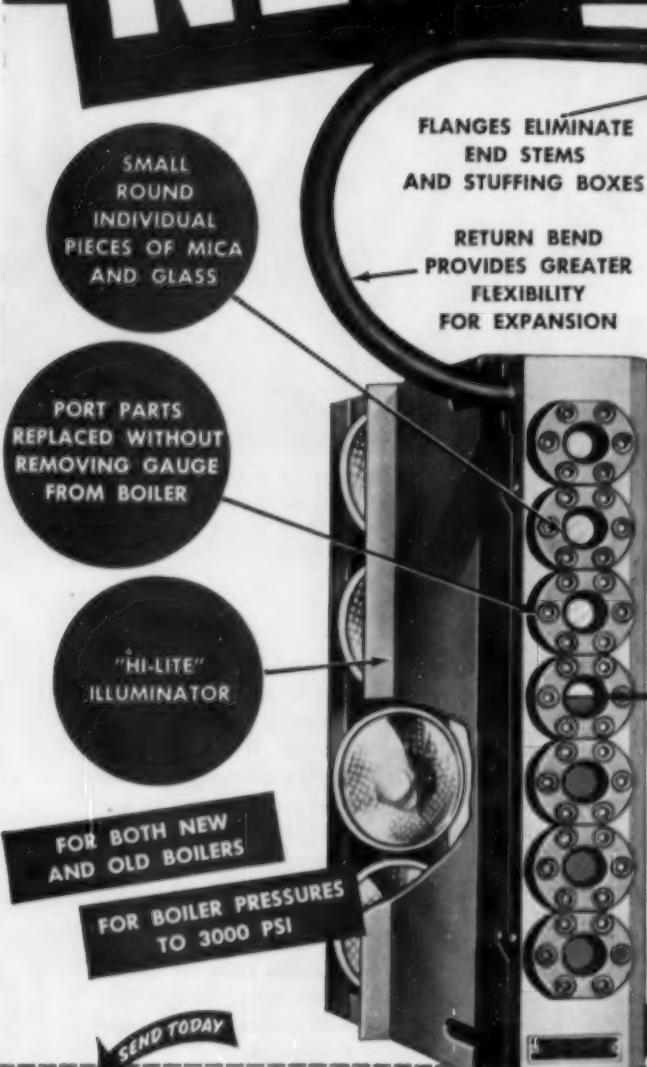
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STAINLESS-CLAD • NICKEL-CLAD • INCONEL-CLAD • MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEELS AVAILABLE ANYWHERE

NEW

DIAMOND "MULTI-PORT" Bi-Color Gauge



DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO

Please send me without obligation a copy of new
Bulletin No. 1174 explaining the advantages of
the Diamond "MULTI-PORT" Bi-Color Gauge.

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"MULTI-PORT" Advantages:

- (1) "Bi-Color" principle shows steam red and water green
- (2) Small round ports instead of long glass strips
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- (4) Simplified high-pressure construction
- (5) Maximum thermal stability for rapid starting
- (6) Easy, inexpensive maintenance . . . in place
- (7) Direct reading . . . basic reference gauge

STEAM SHOWS RED

WATER SHOWS GREEN

The "Multi-Port" gauge has been developed over a four-year period and has been in continuous successful high pressure operation for more than 18 months in several leading central station plants. For additional information, write for new Bulletin 1174 . . . use the coupon below.

WELDED CONSTRUCTION
ASSURES
PERMANENT TIGHTNESS

6962

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO

Diamond Specialty Limited—Windsor, Ontario

MODERN METHODS of Coal Handling



COAL IS RECLAIMED AS NEEDED from the storage pile of a Michigan industrial plant by this Allis-Chalmers 109 drawbar hp HD-15 Tractor with Gar Wood straight blade and wings. It moves about 9 tons of coal at a time. Unit also stores coal, which is brought in by rail. Tractor handling of coal is flexible, can either supplement existing facilities or take over complete job. Permits adding storage areas without installing costly conveyors, tracks, etc. — or abandoning them without leaving money tied up in idle equipment.

Find out more about how Allis-Chalmers equipment can improve your coal handling at lower cost. See your Allis-Chalmers dealer for a demonstration right at your plant, or ask to see the color film showing coal-handling equipment at work. Also, send for free booklet, "Economic Coal Storage."



14 TONS OF COAL AT A TIME is stockpiled or reclaimed at an Eastern utility by this HD-20 Tractor with special Baker coal blade. Blade design takes advantage of tractor's big 175 net engine hp, permits moving up to 15 percent more coal than with regular blade. Repeated trips of 25-ton unit over stockpile compacts coal, helps prevent spontaneous combustion.

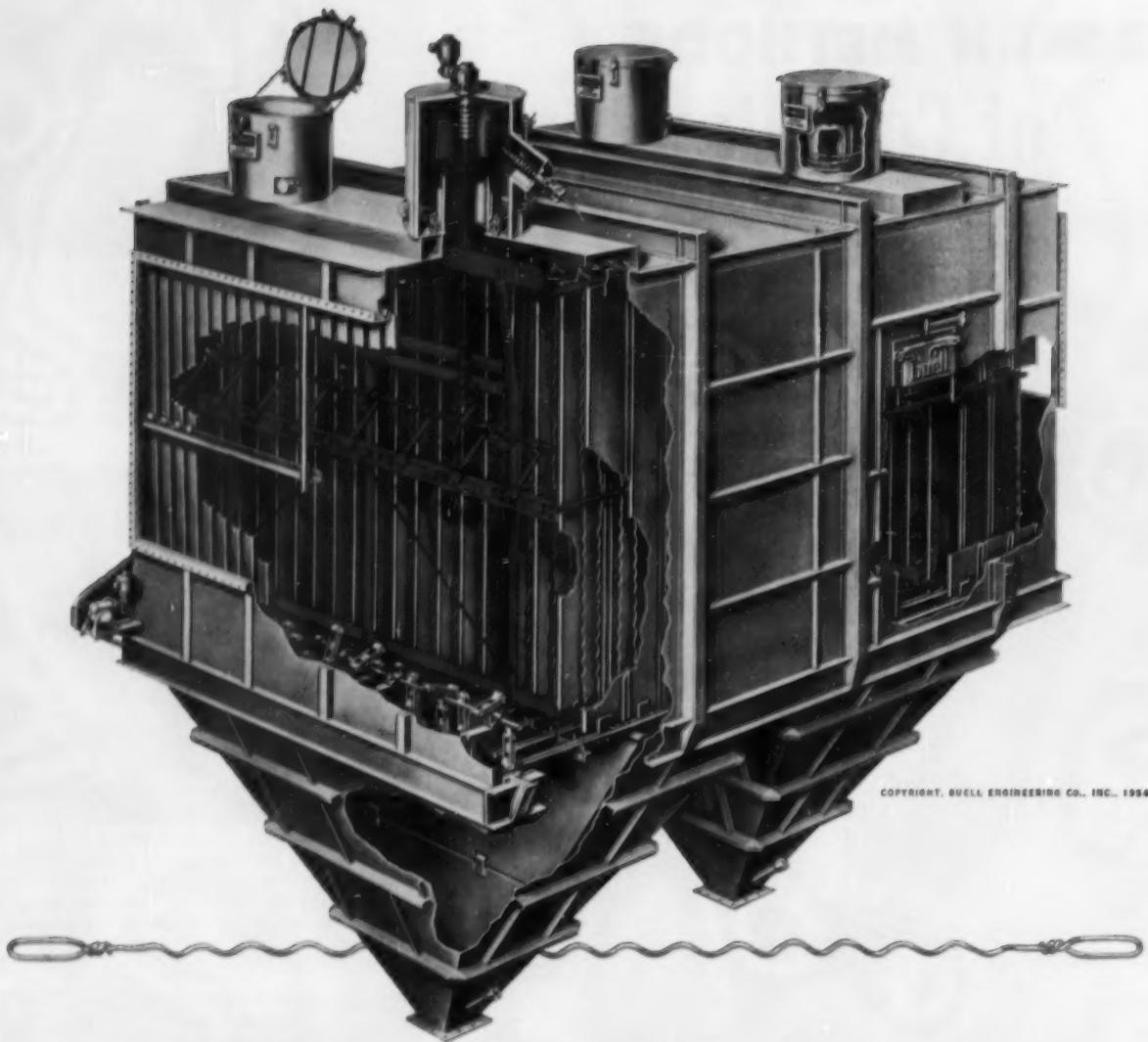


COKE IS STOCKPILED AT A STEEL MILL leveled and compacted by this Allis-Chalmers 72 drawbar hp HD-9 Tractor — then is reclaimed as needed for the plant. Wintertime operation no longer is hindered by freezing of coke surface as it was with system previously used.



VERSATILE HD-9G WITH 3 1/4-YD. (2.8-TON) BUCKET builds storage pile of coal brought to Midwest industrial plant by truck. These coal-handling buckets are available for all four Allis-Chalmers tractors, from 2-yd capacity on the HD-5G to 7-yd on the HD-20G. Blades and other attachments are interchangeable with buckets to widen the usefulness of Tractor Shovels.





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World's Most Effective Dust Collector

Already you have heard about the amazingly high efficiency and low maintenance of Buell "SF" Electric Precipitators. Now...we'd like to tell you about the Buell *exclusives* that make these money-saving advantages possible!

➤ **Spiralelectrodes** permit higher emission than any other electrode...result in unequalled efficiency in industrial dust collection.

➤ **Continuous Cycle Rapping** eliminates "puffing," keeps electrodes constantly clean, prevents re-entrained dust...maintains peak efficiency.

➤ **Positive Flow Control** by specially designed baffles prevents channeling, scouring and harmful eddies.

➤ **Sectionalized Design** permits wider safety margins and more reliable service...keeps maintenance extra simple...eliminates need for complete shutdown.

Write today for a free Brochure which describes *all three* of Buell's proven systems—The Collection and Recovery of Industrial Dust. Dept. 70-A, Buell Engineering Company, 70 Pine Street, New York 5, N.Y.

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MECHANICAL
ELECTRICAL

20 Years of Engineered Efficiency in
DUST COLLECTION SYSTEMS

COMBUSTION

Editorials

A Solemn Reminder

Advances in the art and science of engineering inherently involve certain risks. The success of any given design is dependent upon the extent to which these uncertainties can be forecast, appraised and evaluated. In many instances sufficient data are available to make actual calculations of the uncertainties, hence the term calculated risk. But there are others in which the designer can have only a qualitative sense of the uncertainties and must base his decisions on what might be considered faith in good engineering judgment.

During the year 1954 there were at least three major breakdowns which serve to remind the central station industry of the inherent risks in an advancing technology. Early in the year there were several accidents at the recently commissioned R. L. Hearn Plant of Ontario Hydro. Late last September a mechanical failure within the generator at the 150,000-kw Unit No. 1 at Cromby Station of Philadelphia Electric Company caused considerable damage during a routine test shortly after that station had been placed in service. On December 19 there was a serious accident to the turbine of a recently installed unit at the Ridgeland Station of the Commonwealth Edison Company, in which two operating engineers were killed and damage to the plant was estimated as high as \$10,000,000.

This is not a time to become alarmed and fearful of safety conditions in central stations. By the very rarity of their occurrence, such accidents attract a great deal of attention. Undoubtedly the lessons learned therefrom will be widely publicized in accordance with the admirable tradition of the utility industry of making such information generally available. The lives so tragically lost at Ridgeland cannot be regained, but the memories of these supreme sacrifices in the line of operating duty serve as a solemn reminder of the inherent risks in engineering advances.

Sulfur Elimination From Fuels

The recent Special Study Conference sponsored by the Institution of Mechanical Engineers in London last October on sulfur removal and recovery from fuels brought to-

gether a number of European authorities to exchange views on a subject held to be of prime interest in their countries and of more than passing interest in our own.

The Conference brought out that the main source of indigenous sulfur in Great Britain is anhydrite and gypsum. The 1954 requirements measure 115,000 tons of regular sulfur and 250,000 tons of acid-making sulfur of which total 75 per cent is imported. Yet the coal burned annually in Great Britain contains over 3 million tons of sulfur and only 5 to 6 per cent of it is recovered. Similarly petroleum refined in Great Britain today, amounting to 25 million tons per year, has an average of 2 to 3 per cent sulfur or about 0.6 million ton which could be tapped. But again only 5 to 6 per cent of the available sulfur is recovered from this source. To the Conferees these statistics represented a direct challenge.

The challenge as they saw it was not only the recovery of sulfur from fuels but the elimination or reduction of oxides of sulfur in the atmosphere. A number of papers were presented on the occurrence and removal of sulfur in coal and oil and twice as many on the removal of sulfur from fuel gases. This division is an understandable one in that air pollution control problems have forced a number of industries over the years to inquire into the role and the effect of sulfur products discharged into the air with stack gases.

From the economic standpoint there appeared to be a natural limit to the extent to which sulfur could be removed from coal and oil. Further, the cleaning of power station gases was still uncommon although at least two processes exist and a third (ammonia washing) was said to show experimental promise. The existing processes in Great Britain cost from \$1.12 per ton to \$1.96 per ton of coal burnt. The ammonia process held forth a hoped-for cost of 28 cents per ton of coal burned with an outside possibility of showing a profit eventually.

While the general tone of the Conference promised no quick solution the assembly in a common forum of representatives of the different industries involved, fuel producers and fuel consumers of all stripes, strikes a most encouraging note. The problems sulfur presents in fuel burning and atmosphere pollution are so diverse and involve so many human activities that progress in their control can only come from the pooling of the various talents and viewpoints concerned.

The Present Status of Steam Properties*

By FREDERICK G. KEYES and JOSEPH H. KEENAN
Massachusetts Institute of Technology

With the advent of the supercritical pressure cycle upon the power plant scene, questions have been raised concerning the adequacy of existing steam tables. What are the limitations upon extrapolated data? How long will it take to perform the painstaking experimental work necessary for extending the present tables? As evidenced by the Commentary in our January 1933 issue, COMBUSTION has shown a continuing interest in steam table research and is proud to be among those publishing this ASME Annual Meeting paper by the distinguished originators of the U. S. Steam Tables.

The Third International Steam Tables Conference held in the United States in 1934 reviewed the reports of investigations of steam properties submitted by the investigators from the United States, England, Germany and Czechoslovakia. The reports considered were based upon some ten years of measurement effort begun under the auspices of the ASME, following a meeting of scientists, engineers, and turbine designers in Cambridge at Harvard University during June 1921.

The result achieved by the third conference of 1934 was the definitive International Skeleton Steam Tables, accompanied by estimates of accuracy, or "tolerances," and included the designation of fundamental units, definitions and conversion relationships.

The primary purpose to be served in devising the skeleton tables was to designate at comparatively large temperature and pressure intervals values pertaining to the saturation state of water substance and the superheat region over the entire ranges of these variables which had become accessible to the scientific investigators. The data following from three independent investigations of vapor pressures from 0 to the critical temperature (374.15), the phase boundary volumes of the liquid, the heat capacities of the saturated liquid, and the heats of evaporation were available. In the superheat the enthalpies were available from independently conducted measurements to 550 C (600 C was reached by our British colleagues) and to pressures of 300 atm. The heat capacities of the superheat region were also available from direct measurement to 450 C and to pressures of 200 atm. Joule-Thomson measurements were available over the range 125 to 347 C and to 40 atm. Meas-

urements of the volumes of the compressed liquid phase had been made to nearly 350 atm to the critical temperature. The data on volumes of the superheat extended from 2 cc per g to 150 cc per g, and to temperatures of 460 C. This extensive ensemble of painstaking experimental investigations comprised the basis of the skeleton tables. The published tables became available to anyone, anywhere, for the preparation of detailed steam table which would be considered "International Tables" provided the values contained therein were within the tolerances set by the Third International Conference group.

It was the cherished hope of the conferees in 1934 that the limits of temperature range, 550 C (1032 F) and of pressure, 350 atm (5000 psia) attained in the investigation of water substance would serve all requirements in the science and art of power production for the lifetime of the youngest conference participants. The hope has not been realized for now we envisage the need for accurate data at even higher temperatures and greater pressures.

Nor is this all, for we require far more exact and verified data for the viscosity and thermal conductivity of water substance than exist at present. Finally, it is now highly desirable that a comprehensive investigation be pursued on the relation of the International scale of temperature to the thermodynamic scale. In the scientific sense it is only the latter scale which finds full logical justification when employing the laws of thermodynamics. Indeed we now know, thanks to James A. Beattie's gas

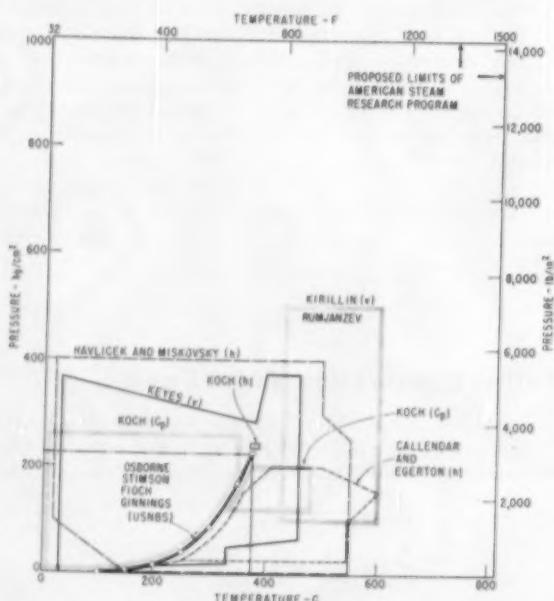


Fig. 1—Pressure-temperature diagram showing limits of work to date and proposed limits for a future research program.

* Contributed by the ASME Research Planning Committee and presented on November 29, 1954, at the Annual Meeting of The American Society of Mechanical Engineers, New York, N. Y. Published complete except for section entitled "The Viscosity and Thermal Conductivity of Water Substance."

thermometric investigations, that the available steam data is consistent in the thermodynamic sense, although there are deficiencies in our knowledge of the scale relationship above the range 0 to 444.6 C.

The satisfying success of the earlier international cooperative effort to perfect our knowledge of water substance, culminating twenty years ago, suggests that the present need for data at higher temperatures and pressures may find fulfillment under a similar organization. It is with this hope that the present statement has been drawn up. In what follows a brief presentation is made of the extent, in terms of the variables, pressure and temperature, of our existing knowledge. The extension to larger values of these variables through a form of international organization adapted to present circumstances is urgent.

Since the 1934 International Conference, considerable new data and important correlations of experimental findings have been reported. Thus may be cited (1) very accurate measurements of essentially the heat of evaporation between 0 and 100 C (August 1939); (2) the development of the means for measuring the change of enthalpy with pressure at constant temperature with data in the range 40 to 125 C, leading to exact values of volume in a region inaccessible to accurate measurement by direct means; (3) the accumulation of data relating to the infra-red spectrum of water vapor in the ideal gas state have been computed; (4) G. C. Kennedy's $p-v-T$ relationships in water to high temperatures and pressures; (5) the direct measurement of $p-v-T$ properties of steam between 531 and 600 C, and to 500 atm; also, (6) data for C_p in the superheat. These valuable contributions to our knowledge of equilibrium states have been supplemented by (7) much work on the transport properties, viscosity and thermal conductivity so vitally important in the applications of heat transfer theory. The results now available, however, appear to require verification.

The proposal is advanced as a point of departure for discussion that additional measurements be obtained to extend the temperature range of verified data to 800 C (1500 F) and 1000 atm (15,000 psia). The quantities proposed for measurement are (1) the enthalpy for steam from 500 C and (2) the $p-v-T$ properties from 500 C, not alone by direct measurement but from measurement of (3) the enthalpy change with pressure at constant temperature. This differential quantity is a direct

Commentary by Joseph H. Keenan

From The Sidelines

I do not usually seek my recreation in technical meetings, but these A.S.M.E. steam research sessions are different. The last one settled all we shall want to know for a long while about the vapor pressure of water. But then, every steam research session has settled some important issue. Once it was the design of a 1/7500th horsepower pump. Osborne needed one for the inwards of his little copper-nickel boiler with the gold-gasketed joint. The pump had to be efficient, not just a paddle wheel. And when things got going that pump stood several years of operation, its tiny shaft turning in a water tight packing that sealed against boiling water at 800 pounds per square inch. Failure came only when the time had arrived to build a new apparatus. What more could one ask of any design?

I saw the experimental data start to trickle in as I sat through those December meetings. A few Joule-Thomson coefficients appeared in 1922. In 1923 these measurements from Harvard had worked their way into high pressure regions. Before that we had no experimental knowledge of superheated steam above 250 pounds per square inch, but Davis and Kleinschmidt had now pushed on to almost 600 pounds. Two years later these data reappeared, metamorphosed into a steam table.

In 1927 Keyes spread before us fifty-two volume measurements of a consistency unprecedented in measurements on superheated steam. The highest pressure investigated was 3900 pounds per square inch, the lowest was 1400 pounds. Here was no hesitating approach to the formidable region of high pressures, it was a bold invasion of its fastnesses. It took some time to coax Keyes and Smith down to the more civilized regions below a pressure of 1400 pounds. They had made measurements at 5200 pounds per square inch and had calibrated their pressure gages up to 8400 pounds before they descended to enter more prosaic territory. Back in 1927 they had not yet closed the large gap between 600 and 1400 pounds per square inch, but they had triggered off the next steam table development.

Two years later Keyes closed the gap and was proceeding farther on his southerly course. Experimental equipment and technique were being perfected. His first bomb of pure nickel was a source of some annoyance because its walls oozed minute quantities of non-condensable gases into the steam space. It finally ruptured, making way for the use of the more satisfactory stainless steels. The constant temperature bath surrounding the

bomb was made ten times as constant, thermometry was improved, the point of separation between the vapor in the bomb and the liquid in the connecting tubes was more sharply defined. And so it happened that a year ago Keyes and Smith told us of a most extraordinary year's work, covering in twelve months the entire range of all their previous experimentation. Suiting equipment and method to each particular region they measured with a precision beyond their own previous performance all the way from 200 pounds per square inch to 5100 pounds. Less spectacular as exploration, perhaps, than some of their earlier work, it was nevertheless the most impressive body of experimental data on superheated steam that had ever been produced in the course of one calendar year.

In the meantime Osborne and his colleagues from the Bureau of Standards were telling us about water and its vapor up to 800 pounds per square inch. Their early descriptions of their methods contained frequent reference to alpha, beta and gamma experiments. But later this Hellenic aetherianism gave way to the less cryptic discussion of latent heats and enthalpies. They gave us the calorimetric properties of saturated water and its vapor to a precision of one part in 2000, and they deduced through the Clapeyron relation specific volumes of saturated vapor which agreed extremely closely with those reported by Keyes and Smith.

Experimental data from Germany, from England, from Czechoslovakia, analytical studies from everywhere, in fact all the varicolored threads that make up the fabric from which steam tables are made were woven together at the annual meetings.

There are signs and portents foreshadowing an early close of the American steam research program. It should not be so. An organization of skill and experience should not be dispersed until it has acquired all information within its reach. I hope to hear Osborne a few years hence tell us about the specific heat of superheated steam to his usual one part in thousands. I look forward to the reports from Keyes on Joule-Thomson and constant temperature coefficients in the low-pressure range when we need them most. I expect to see him build the structure of the thermodynamic temperature scale which must soon replace the platinum standard. December will remain the prominent month in my calendar, if steam research goes on.

Joseph H. Keenan

Stevens Institute of Technology

COMBUSTION—January 1933

measure of the departure of a fluid from the ideal gas state and leads to a valuable confirmation of the accuracy of the directly measured $p-v-T$ properties. The apparatus for measuring the enthalpy change with pressure can be designed to permit (4) the measurement of specific heats, and (5) Joule-Thomson coefficients.

In addition to the foregoing equilibrium quantities, it is proposed that the viscosity of steam be measured to at least 800 C and to pressures of 1000 atm. Similar ranges are proposed for the thermal conductivity.

The relation between the International Scale of temperature and the thermodynamic scale has been determined recently to the sulfur boiling point. The results of the foregoing scale investigation should, however, be confirmed and extended to the silver calibration temperature, 960.8 C.

Fig. 1 shows in pressure-temperature coordinates the areas covered by the investigations of the first international effort, and also included later investigations to date. G. C. Kennedy's work, which extends to 1000 C (1832 F) and to nearly 2500 atm (37,000 psia) is not represented in Fig. 1. Professor Kennedy is verifying

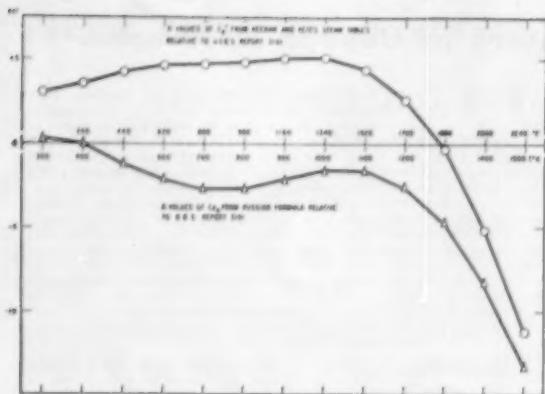


Fig. 2—Variations in C_p with respect to National Bureau of Standards Report No. 3103

his measurements on steam, particularly in the region of immediate interest for steam tables. In consequence of this circumstance, these extensive measurements will be reviewed at a later date. The reported results of investigations undertaken to test the thermodynamic consistency of the existing body of experimental results, and making use of the temperature scale comparisons to the sulfur point (444.6 C) are satisfying. It follows therefore that new investigations extending the old limits of pressure and temperature may start out with a tested array of experimental findings to 550 C and about 350 atm. In addition to this encouraging background the correlating equations evolved in dealing with the existing data will serve to provide reasonable "expectations" of magnitudes in the extended region. Thus the details of the design of measuring equipment can be determined with the advantage of knowing the order of magnitude of values sought.

The U. S. Steam Tables (J. H. Keenan and F. G. Keyes, "Thermodynamic Properties of Steam," John Wiley and Sons Inc., New York, 1936) was compiled with the knowledge that definitive values for C_p could not

be had until further data were available relative to the infra-red spectrum of water vapor. This definitive information is now available¹ and Fig. 2 will convey an impression of the differences in C_p used in two steam tables relative to National Bureau of Standards values, while Fig. 3 represents differences in the enthalpy quantity $\int_{T_1}^T C_p \, dT$ based on the definitive C_p values and the same integral derived from the values of C_p employed in the U. S. Tables and the recent (1951) Russian Tables. At the top of the figure the differences of the 1 kg/cm² enthalpies as tabulated in the two foregoing tables are exhibited. The Russian Tables make full use of the International Skeleton Tables of 1934, using C_p values resulting from a Russian treatment of the spectral data. The Russian Tables tabulate values to 700 C (1292 F) and 300 kg/cm² (4270 psia). The latter tables also contain detailed tables for viscosity and thermal conduction based exclusively on Russian investigations of these transport properties.

The tabulated enthalpies for several constant pressures from the U. S. and Russian Tables have been compared and the differences appear in Fig. 4. A similar chart of the volume differences is represented in Fig. 5.

In 1950 a paper appeared (by W. A. Kirill and L. L. Rumjanzev in *Elektritscheskie Stanzii*, Vol. 21, No. 12 pages 8-14) giving values of pressure and volume at six temperatures, 431.34 C (808 F) to 600 C (1100 F), and to pressures of 500 atm (7100 psia). These data provide an extension in temperature of 140 deg C and in pressures of some 150 atm over the limits of the directly measured values of volume available to the 1934 conference. Fig. 6 gives an impression of the relation of these new measurements to similar values computed from the Russian Tables equation of state. Definite knowledge is lacking regarding the use of the new Russian volume data in preparation of the 1951 tables.

Fig. 7² gives a survey of comparisons representing

¹ National Bureau of Standards Report No. 3103.

² Fig. 7, has been reproduced from National Bureau of Standards Report No. 2535, Fig. 2, of that report.

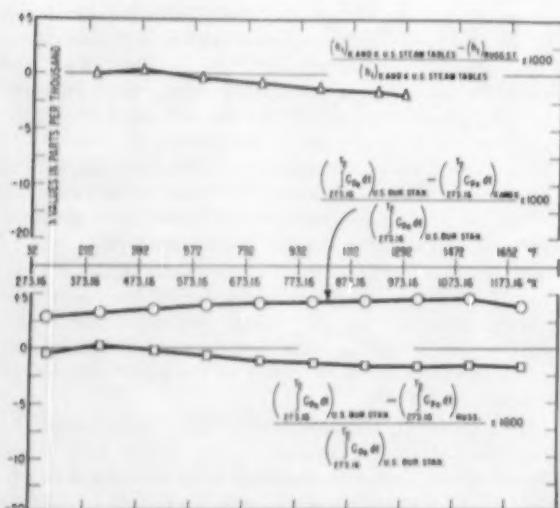


Fig. 3—Differences in enthalpy quantity with respect to Bureau of Standards, Keenan and Keyes and Russian data

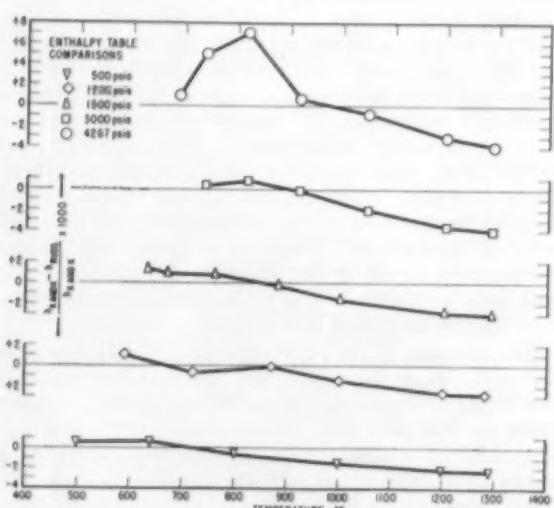


Fig. 4—Comparisons of enthalpy values in U. S. and Russian tables

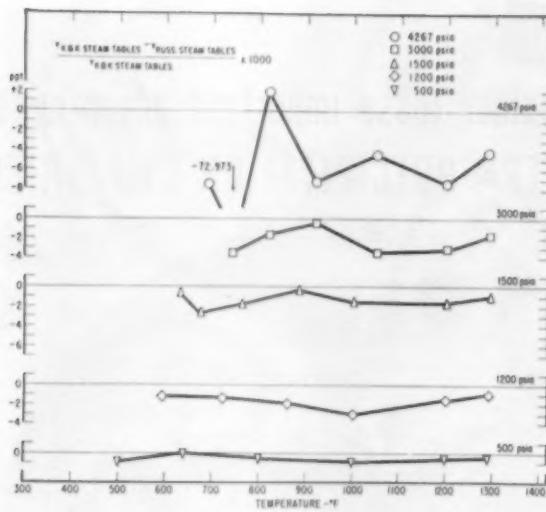


Fig. 5—Comparisons of specific volume in U. S. and Russian tables

differences between the reported pressures of the recent Russian p - v - T measurements and pressures computed from an equation of state based on the Skeleton Tables p - v - T data. Fig. 8 is a graph comprising pressure differences between the Russian data and pressures computed from the equation of state.

Conclusions

The present status of the 1934 International Skeleton Tables data may be summarized as follows:

1. The accuracy of the data is established by the test of thermodynamic consistency when the test is carried out employing the results of the recent experimental comparison of the International scale temperature with the thermodynamic scale.

2. The additional experimental data reported for water substance since 1934 indicates no trend which in any way reflects against the accuracy of the 1934 table. There is an exception, however, in the case of the 1950 Russian data which extends beyond the 1934 superheat volumes in temperature and in pressure. Pressures computed using the equation of state based on the Skeleton Tables superheat data fail of agreement with the new Russian data, being smaller by the order of one per cent.

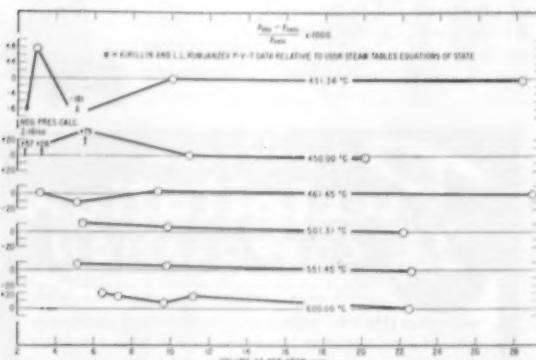


Fig. 6—Comparison of Russian data relative to equations of state

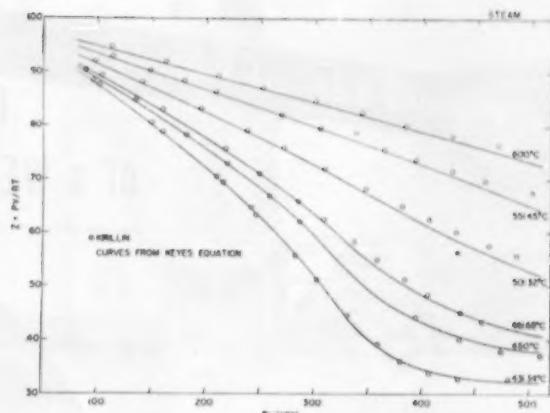


Fig. 7—Comparison of calculated and experimentally derived compressibility factors

3. The need of additional experimental data extending beyond the range of the 1934 Skeleton Tables is urgent, not alone for present design needs but for turbine design suited to even higher pressures and temperatures. The higher limits proposed are 800 C (1500 F) and 1000 atm (15,000 psia). With contemporary materials and the experience accumulated earlier, together with the 1934 data of proved accuracy as a base upon which to build, these very high limits are believed attainable.

4. The design treatment of heat transfer equipment depends upon reasonably accurate data for viscosity and thermal conductivity. It is imperative that the present discordant array of transport quantities be disposed of through new research. The viscosity and thermal conductivity should be known at low pressures with an accuracy of at least one per cent to 800 C and to pressures of 200 atm to temperatures of 400 C. The pressure effect falls so rapidly with temperature increase that it need not be measured to 800 C.

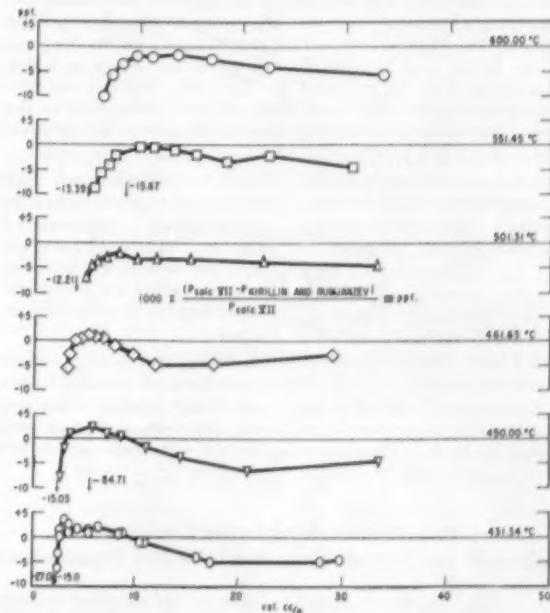


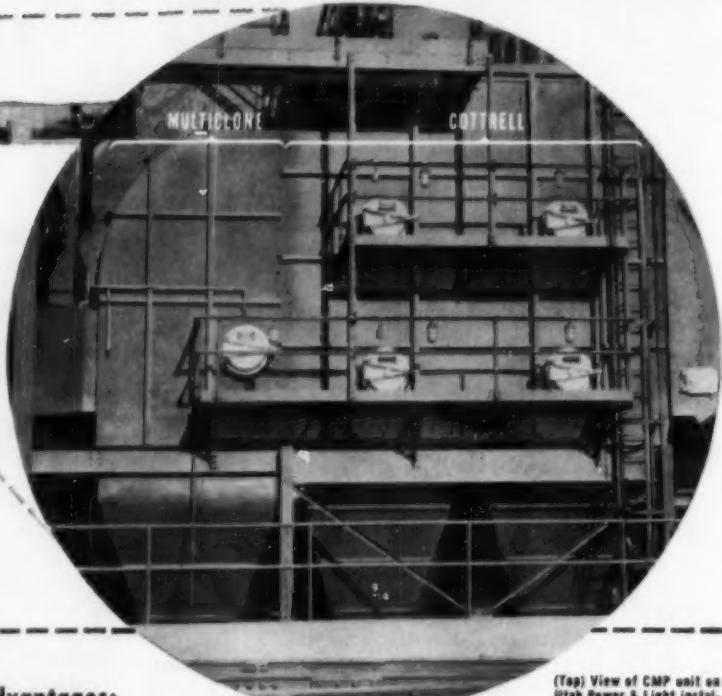
Fig. 8—Pressure differences between Russian data and equations of state

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(Top) View of CMP unit on Utah Power & Light installation. Note compactness of unit. (Above) Close-up of same installation.

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Fig. 1.—Model of the Pennwood Station of the Sparrows Point plant of Bethlehem Steel Co. illustrates its attractive appearance, compact layout

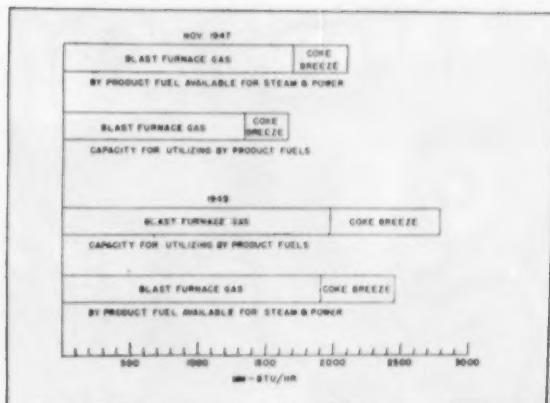


Fig. 2.—Chart above compares byproduct fuels available for power and steam generation for both 1947 and 1949 against installed byproduct fuel-burning capacity

Bethlehem Steel Balances Energy Needs Against Byproduct Fuel Production

By J. M. SPENCER

Assistant Fuels Engineer, Bethlehem Steel Co., Sparrows Point, Md.

Immediately after World War II the steel industry expanded its production facilities at a rapid pace. The Sparrows Point Plant of the Bethlehem Steel Co. included an integrated power plant as a vital adjunct to their expansion program and this inclusion has continued to give beneficial operating returns.

PENNWOOD Power Station, Fig. 1, at the Sparrows Point Plant of Bethlehem Steel Co. owes its existence to a continued desire for better utilization of byproduct fuels. Over the years a number of plans had been developed to meet this aim. But for one reason or another all were discarded until after World War II. By 1947, though, studies indicated that the fuel available and the plant electrical load were such that an electrical generating station would be attractive economically. At that time the byproduct fuels were used principally for raising steam at low pressure, for stoves, soaking pits and coke ovens plus gas engines driving small electric generators and blast furnace blowers. An electric generating station would fit into this picture very comfortably and be an excellent means of using up a growing excess of by-product fuels.

Plant Needs

Steam needs for a plant the size of Sparrows Point run

extremely high. There were in existence at the time of the 1947 studies a number of steam-producing facilities. These units were in addition to the planned Pennwood Station and most of them are still very much in service. They include: (1) two boiler houses that together have nine boilers supplying better than 750,000 lbs per hr of steam at 275 psi with blast furnace gas or oil as their fuel, (2) 26 waste-heat boilers developing some 380,000 lbs per hr more steam at this same pressure level, (3) two boiler houses generating around 250,000 lbs per hr of steam at 175 psi (One of these boiler houses uses coke oven gas and oil for fuel while the other employs coke breeze.) (4) another 8 waste heat boilers delivering up to 120,000 lbs per hr of steam at 175 psi. All told the various smaller boiler houses and waste-heat units then accounted for about 1,500,000 lbs per hr of steam, and still do.

With the plant growth by 1947 providing still greater quantities of byproduct fuels, Fig. 2, the possibility of meeting some of the plant's electrical load with a modern generating station seemed worth while. At that time the electrical load was anticipated to reach a peak of 180 mw with 75 mw of it coming from the proposed Pennwood Station. It has since gone beyond the anticipated 180-mw peak. Along with it there has been an accompanying increase in steam needs. As a result the new power station at Sparrows Point has had two distinct stages of development.

The Power Plant

At start-up Pennwood consisted of two 425,000 lbs per hr steam generators firing blast furnace gas, oil or coke

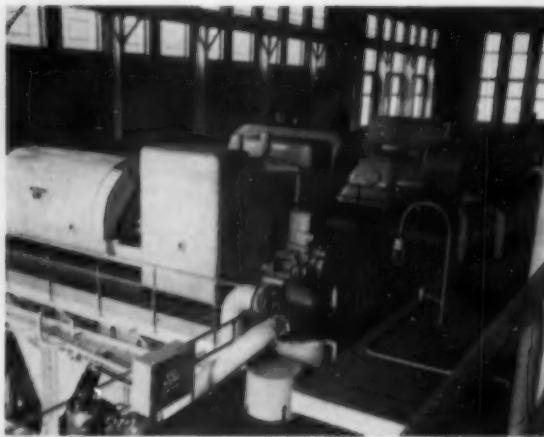


Fig. 3—Turbine room view shows most recently installed 20,000-kw back-pressure turbine generator, hydrogen cooled, in the foreground

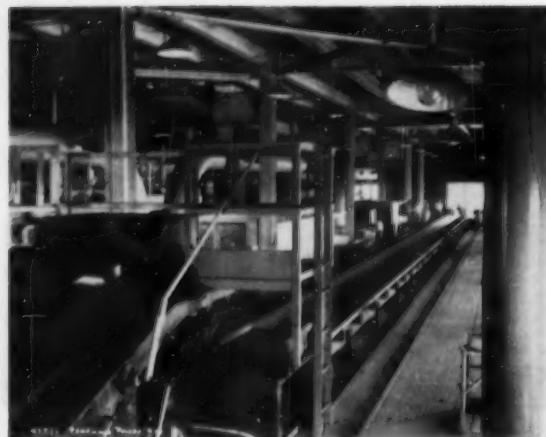


Fig. 4—Coke breeze is moved across the boiler room for delivery into the plant bunker system by the belt conveyor pictured above

breeze. There were two ASME preferred standard 30,000-kw hydrogen-cooled generators receiving steam at 850 psig and 900 F, TT, at the turbine throttle. Recently a 20,000-kw back-pressure turbine generator, hydrogen cooled, exhausting to a 275 psi header was added, Fig. 3. At the same time a new 475,000-lb-per-hr steam generator went into service. Like the earlier installation it burns blast furnace gas, oil or coke breeze. The combined boiler and non-condensing turbine ideally meet the requirement of more steam and more electricity. Now the total steam generating capacity of Pennwood amounts to about 1,325,000 lbs per hr of steam as against 850,000 lbs per hr originally and its electrical generating capability totals 100 mw as against the original 75 mw.

The Patapsco River, on which the plant is located, is in a tidal area and at times subject to extreme variations in water level. Past experience had demonstrated that both high and low waters could disrupt operations. So a special attempt was made to meet these problems. The turbine hall floor at Elev. +3.0, is 4 ft below the maximum expected water level and the bottom of the intake tunnel, at Elev. -16.0, stands 8 ft below extreme low water. This arrangement allows a variation in water level of 15 ft, enough, it is felt, to meet any eventuality.

Separate intake tunnels permit a certain flexibility since either one may be isolated by stop logs and the station operated from the other, although at reduced capacity. Condensers, split on the vertical center line, make it possible to clean either half without taking the unit off the line. Automatic chlorinating equipment keeps up the condenser heat-transfer rates.

Boiler Equipment

The steam-generating units can fire blast furnace gas, oil, or coke breeze. A traveling grate stoker, 24 ft by 28 ft, Figs. 4, 5, with overfire air injected at the nose of the rear arch handles the coke breeze. Nine combination gas and oil burners are set in the rear wall of each boiler and feed either blast furnace gas or oil.

Superheat control in the original two 425,000-lb-per-hr steam generators is by means of a bypass damper. A tubular dust collector placed between the economizer and air heater can also be bypassed.

The air heater on each unit has two paths for the forced draft. The upper half supplies air at 600 F for the combination gas and oil burners. The lower half furnishes stoker air at 250 F. An automatic tempering damper admits the necessary cold air quantities to keep the stoker air within limits that will not damage the stoker. This construction also limits the corrosion difficulties on the cold end of the tubular preheaters.

The latest 475,000 lb per hr boiler, Fig. 6, follows the general design principles of its predecessors except it employs a spray desuperheater for superheat temperature control.

Present Steam Supply

Under peak-load conditions the original two boiler and two turbine installations at Pennwood delivered up to 250,000 lbs per hr of steam for auxiliary drives and for bleeding to the 250 psi system. This steam was reduced in pressure through two desuperheating stations, operating in parallel, to 275 psi before admitting it to a 4000-ft-long, 24-in. steam main connecting to the older, low-pressure plant system, Fig. 7.

The new 475,000-lb-per-hr unit has almost all its production available for this low-pressure system after it has passed through the new non-condensing turbine unit. The original desuperheating stations are normally closed, but automatically come into service if the non-condensing turbine trips out.

Station makeup enters the cycle at the deaerating heater. This makeup comes from condensate supplied by consumers on the 250-psi system, thus eliminating a capital outlay for water-treating equipment at the station itself. All treatment now is internal and involves phosphate, sodium sulfite and caustic soda. The pH of the entering feedwater averages 7.5 to 8.0 which is held too low for good economizer life. Recirculating boiler feedwater corrects this condition, though.

The present breakdown of 250-psi steam production for plant needs by the different generating facilities gives Pennwood 9,600,000 lbs per day; the older low-pressure boiler houses, 18,625,000 lbs per day; and the various waste-heat boilers, 8,200,000 lbs per day; for a grand total of 36,625,000 lbs per day.



Fig. 5—Traveling grate stoker, 24 by 28 ft, fires coke breeze. It has an overfire air injection point at the nose of the rear arch. Gas and oil burners mount on rear wall

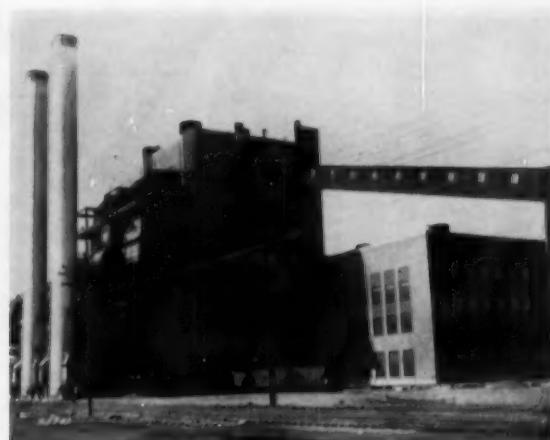


Fig. 6—External view of Pennwood Station shows that all heat recovery equipment for the station, dust collectors, and induced draft fans stand outside

The primary users of steam at high-pressure level are the Pennwood turbine generators. Other turbo generators, mostly for 25-cycle service, turbo blowers and coke oven exhausters are the principal users of 250-psi steam. The miscellaneous users account for the 150-psi steam load although there is a very sizable space heating load in the winter. Table I shows the relation between the major steam requirements regardless of pressure.

Fuels and Fuel Handling

Of the various fuels available to meet these steam needs the percentage each furnishes breaks down as follows: blast furnace gas, 60.9%; coke breeze, 14.6%; waste heat, 19.8%; fuel oil, 4.6%; and coke oven gas, 0.1%.

The most important from the standpoint of quantity is blast furnace gas. At Sparrows Point the blast furnace gas system consists essentially of a large main running east and west the full length of the blast furnace section. Each of the nine furnaces discharges its gas into this main and each consumer draws its gas from this main.

Gas in this main is "dirty" or "rough" gas and depending upon its eventual consumer service may be cleaned by passing it through disintegrators or precipitators where the dust loading is reduced to as little as 0.004 grain per cu ft. But in addition to the cleanliness factor, as far as specific consumer requirements go, is the one of priority.

The blast furnace auxiliaries have first call on any gas. Then the production units, such as soaking pits and coking ovens, get theirs. And finally the steam-generating equipment and the gas engines. The reasoning is straightforward. The coke ovens can use coke oven gas and the steam boilers, oil. The gas-driven electric engines may be scheduled off if gas supply proves inadequate but if they are left running their priority is equal with the gas-driven blowers on the blast furnaces.

Since the gas mains serve as the only storage space for gas and gas production varies from considerable to relatively little a good system of controls is provided. These controls serve two prime functions, dispatching and safety. Actually the two functions interlock.

For example the prime requirement of any safety con-

trol is to protect the gas distribution system and the gas consumers from either extremely high or dangerously low gas pressure. The gas is toxic in nature and is piped into the enclosed areas of the boiler houses, gas engine rooms and various gas cleaning and hoisting stations so that these areas require an infallible over-pressure protection system. The low pressure condition is even more dangerous. It is at this time that the hazard of an explosive mixture is most likely to occur and steps must be taken to shut off gas to consumers.

High-Pressure Gas Control

There is one operating requirement that helps in the control of high pressure in the gas mains. This is the need to remove the quantities of dirt and water, even after the primary washers have done their work, that carry along with the gas in its travel through the mains. Water sprays have been placed in these mains to do this job. Then a special system of drains remove the accumulated water continuously. Each drain is equipped with a seal that provides a hydraulic head greater than the static pressure in the gas mains so that the seals will not blow and release gas into the atmosphere. But each of these hydraulic controlled seals needs protection against an increase in static pressure within the mains that could conceivably overcome their hydraulic head.

Gas bleeders of the burning type, operated by pressure regulators set well below the minimum seal hydraulic head, handle any over-surges in gas pressure. These pressure regulators employ oil as the operating medium. An oil storage tank and two oil pumps are supplied with each installation. The pumps have one electrically driven unit and one steam-driven with the oil pressure developed by the electric pump closing the steam admission valve to the turbine-driven unit. In this way failure of the electric-driven unit for any reason causes the steam unit to operate. At the same time an alarm signal flashes at some convenient operating station.

There are times, however, when pressure surges in the system occur too fast for a bleeder to relieve the pressure before it can build up to a dangerous point. One seal, then, is designed to blow at a pressure point below that of any other seals in the system. It has to be of rela-

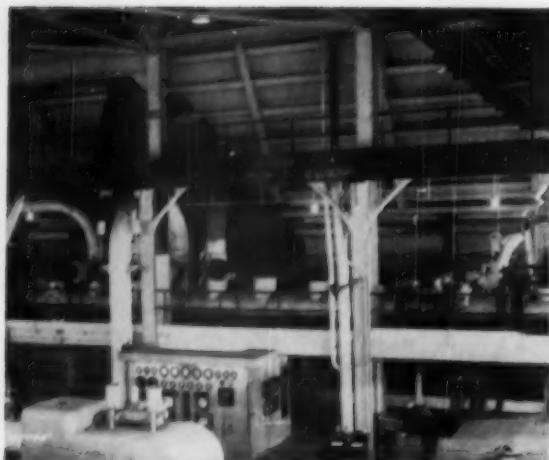


Fig. 7—Two desuperheating stations, operating in parallel, reduce steam pressure from Pennwood to 275 psi before it is admitted to older low-pressure piping system

tively large capacity to give quick relief and located in a comparatively open area for safety of personnel. Further it must be supplied with a heavy supply of water so the seal can be re-established quickly. Because of the toxic nature of the gas any seals at points where the gas is pumped into buildings should be the deepest on the system.

Low-Pressure Gas Regulation

A combination pressure and safety regulator device serves to safeguard consumers from the explosive mix-

ture hazard of low gas main pressure. It consists of a double diaphragm top connected by a balanced arm. One top controls the line pressure during normal operation and the other assumes control of the regulator element when supply gas pressure drops down to a predetermined minimum.

This class of regulator constantly in operation has little chance to fail in event of an emergency. A standby type of control that goes into service only at the time of a gas supply failure needs frequent and thorough check-ups as to its operating ability to work when required.

The low-pressure safety controls offer an excellent means of establishing automatic distribution. By adjusting the pressure at which the controls shut off the gas supply to the various consumer equipment it is possible to eliminate consumers in order of preference as gas supply falls off. Mills and boilers where more than one fuel is available are shut off first.

Conclusion

The Pennwood Power Station represents an excellent example of the benefits of a well-integrated power house to a large working steel mill. It affords a means of disposing of byproduct fuels almost as fast as they are formed and in a manner that benefits the industry without creating a problem to its neighbors.

TABLE I—AVERAGE STEAM DISTRIBUTION

	M. Lbs. per Hour	% of Total
Generation of electric power	1190	49.0
Blast furnace blowing	480	19.7
Coke oven exhausters	90	3.7
Process and miscellaneous steam	520	21.4
Auxiliaries	150	6.2
Total	2430	100.0

Turbine Blade Temperature Telemeter

A complete instrumentation system for remote indication of gas turbine blade temperatures has recently been designed by M. L. Greenough of the National Bureau of Standards for the Navy Bureau of Ships. The system includes special high-temperature resistance thermometers that withstand large centrifugal forces, an inductive commutator that transmits signal information from the high-speed rotor to external stationary equipment, and electronic circuits that interpret the telemetered signals as temperature measurements. Tests on turbines under actual operating conditions indicate that temperature measurements may be made with the instrumentation system to an accuracy of better than ± 25 degrees F at temperatures up to at least 1400 degrees F, where more conventional methods do not apply.

An essential element for any instrumentation system measuring the temperature of moving turbine parts is a means for taking information from the sensing element in the blades and for transferring it through a coupling mechanism to stationary locations outside the rotating machinery. At low speeds, the slip-ring or commutator and brush arrangements are commonly used. At high speeds, however, or in the presence of oil or water vapor,

maintenance of good contact for efficient and reliable signal transfer becomes difficult.

New alternatives to the conventional arrangements are their inductive counterparts, the "inductive slip-ring" and the "inductive commutator". Both have been devised, but the latter has been developed more fully at NBS for inclusion in the instrumentation system. Essentially the inductive commutator consists of a number of pairs of input and output coils on the rotating shaft, with one stationary set of energizing and information-receiving coils mounted on the turbine frame. Rotation of the shaft brings each coil pair into and out of coupling with the stationary coils. Each channel or set of rotating coils is sampled periodically with rotation; thus signal information is sequential in nature. This development offers several useful advantages. Since the inductive commutator is a non-contacting device, there is no wear problem. Large vibration amplitudes have virtually no effect upon the transfer properties. The presence of oil or water vapor also has no appreciable effect upon the signal transfer because the coupling is inductive between low-impedance windings. Moreover, the shaft may be run in either direction without modification of the unit.

Bare Tube Walls on Slag-Tap Furnaces

By PROF. DR. ING. RICHARD
DOLEZAL

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Over the last year or two a series of reports have appeared on the design and operational experience of Czech-built, large-sized high pressure boilers with slag-tap furnaces. This particular one discusses the reasons for choosing certain designs and re-examines them in the light of operational data.

PRACTICAL experience with slag-tap furnaces in various countries favors a furnace construction employing bare tube walls rather than a refractory-lined one for steam-generation purposes. The advantages are many.

While slag does build up on bare tubes it drops off periodically so that the average heat transfer rate and hence steam generation rate is higher with the bare tube than with refractory-covered installation. In fact with bare tubes very high local heat absorption rates develop which may amount to 500,000 k cal/m²hr. Further, bare tube walls are simpler and cheaper to manufacture, and they eliminate one difference between the slag tap and the dry bottom furnace which is an advantage in size and type standardization.

From the viewpoint of conversion of dry bottom to slag tap furnaces (an acute problem in Europe because of the constant decrease of coal quality) a design calling for bare tube wall construction requires only that the bottom be rebuilt and a slag removal system installed. This assumes, though, that the center to center spacing of the original tube wall is not too great. At the present writing most slag-tap furnaces in Czechoslovakia have refractory-faced tubes. The bare tube wall design is of relatively recent date there.

Bare Tube Wall Design

The earlier slag-tap furnaces of bare tube design employed welded-on fins about 1 in. wide and about $\frac{1}{2}$ in. thick. The gaps between fins did not exceed 5 mm, and the vertical spacings ran about 50 mm, Fig. 1. The fins, consisting of flat bars of soft carbon steel, were to protect the furnace lining from the effects of slag. Since they were welded directly to the tubes they increased the heat absorbing surface of the tubes and, in effect, formed a continuous metal wall which prevented formation of a permanent, strongly adhering slag layer on the wall.

The fin width, though, could not be arbitrarily chosen since the fins absorb radiated heat from the flame which in turn raises the fin temperature from its base at the tube to its free end. The average temperature of the fin could not exceed 550 C or the edges of the mild steel fin would burn off. The following formula, $b = 3700 \sqrt{s/q}$, mm gives the maximum permissible fin width, b , in mm for a given thickness, s , in mm, and a given heat absorption rate for the tube of q , in k cal/m²hr. Its application is limited, though, to fins subjected to heat radiation from only one side.

Over and above the restrictions fin size and spacing imposed were the added ones of fabrication difficulties.

The welding on of the fins proved to be an expensive process and required subsequent heat treatment particularly if the tubes were made of alloy steel. In addition local piercing of the tubes could occur during the welding process.

Recent practice in large boiler construction has been to employ bare tube walls with the tubes on close center spacing. This construction applies especially where tubes are relatively inexpensive. In such cases if the ratio of $t/d = 1$ (where t = center to center spacing, Fig. 3, and d = tube dia.) fins need not be used, Fig. 2. Such a wall behaves the same as a finned wall as far as slag buildup is concerned.

This situation was found to hold true in rebuilding dry bottom furnaces for slag-tap operation. In some in-

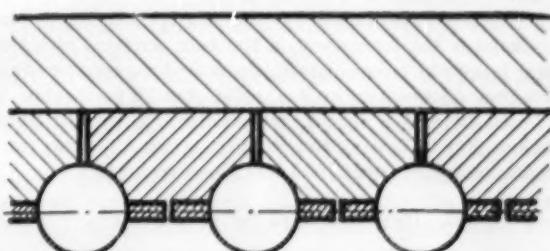
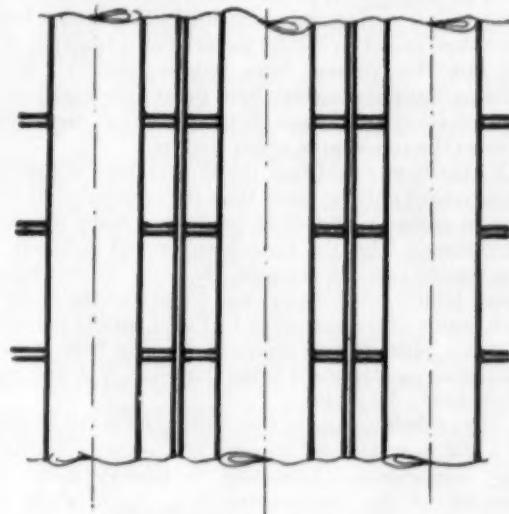


Fig. 1.—Earlier bare tube, slag-tap furnaces used welded-on fins about 1 in. wide and about $\frac{1}{2}$ in. thick with 5-mm gaps between fins.

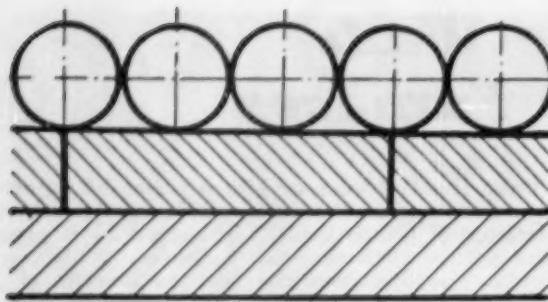


Fig. 2—Recent Czech practice in slag-tap furnace construction employs the bare tubes alone placed on close centers

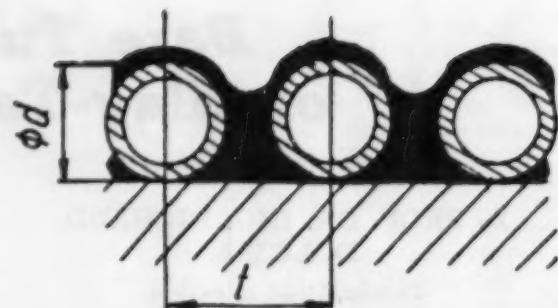


Fig. 3.—Czech boiler wall design establishes a ratio of t/d where t = center to center spacing and d = tube dia.

stances bare tube walls with tube spacings larger than the tube diameter, $t/d > 1$, experienced a molten slag action that not only covered the tubes but filled in the inter-tube space, Fig. 3, so the refractory behind the tubings was undamaged. In a specific case (3) where good results were obtained with such a wall the tubes had a 70-mm dia. and a spacing of 110 mm, i.e., a t/d ratio of 1.57. The simple bare tube wall is a considerable advantage over the more complex finned tube design.

While the above example indicates a considerable tolerance for the t/d ratio actually the maximum allowable ratio must be carefully chosen. Otherwise, the lining behind the tubes can melt off if surface temperature gets too high to permit a protective layer of solidified slag to form. This surface temperature for the lining behind the tubes, called t_w , can be pictured as a function of the t/d ratio for various flame temperatures, t_m , Fig. 4. This part applies to clean bare tubes only because their cooling effect with respect to the lining decreases as soon as the tubes carry a slag coating.

Earlier it was held that the temperature of the lining surface need only be lower than the melting point of the slag to ensure a protective solid layer being formed on its surface. This has since been proved incorrect. In one specific case, for example, the flame temperature ran about 1600°C, the t/d ratio was 1.7 so that the lining surface temperature, according to Fig. 4, would not exceed 1080°C. The melting points of the slag from the coals burned never decreased below 1200°C. Yet melting off of the lining did occur.

The probable cause of this melting off is the formation of a low melting point eutectic of the firebrick with the slag components. According to literary data (4) a eutectic of the components SiO_2 , Al_2O_3 , CaO , FeO , typical of the elements in firebrick and slag, may have melting points even below 1000°C.

Another explanation of the above-mentioned phenomena is the formation on the tube surfaces of a thin slag layer which considerably decreased the cooling effect. In this possibility the t/d ratio should preferably be chosen to give a surface temperature, t_w , of the lining below 900°C. According to Fig. 4 the t/d ratio for a flame temperature of 1600°C is about equal to 1.4.

Heat Stresses in the Tube Walls

At the instant a slag layer drops off a bare tube wall high heat absorption rates of thermal flow can develop. In special cases this sudden, sharp increase can produce

difficulties. Such a special case occurs in natural circulation boilers operating at very high steam pressures (over 150 atmospheres) in which the walls are made of large diameter tubes. Some American plants have installed tubes with wall thicknesses exceeding 10 mm although made of alloy in contrast with the maximum permissible thickness of 7 mm for steam generating tubes in Czechoslovakia and other European states.

Thick walls do not withstand high heat absorption rates very well since the high temperature gradients across the tube walls bring about heat stresses from the different expansion rates of the inner hot and outer less hot surfaces of the tubes. This applies especially to tubes of alloy steel which have lower heat conductivities than mild carbon-steel tubes.

Obviously the presence of a permanent refractory lining and a permanent layer of slag in the tube walls of a slag-tap furnace reduces heat absorption rates and also heat stresses in the individual tubes making up the wall. If the slag layer drops off locally from a bare tube

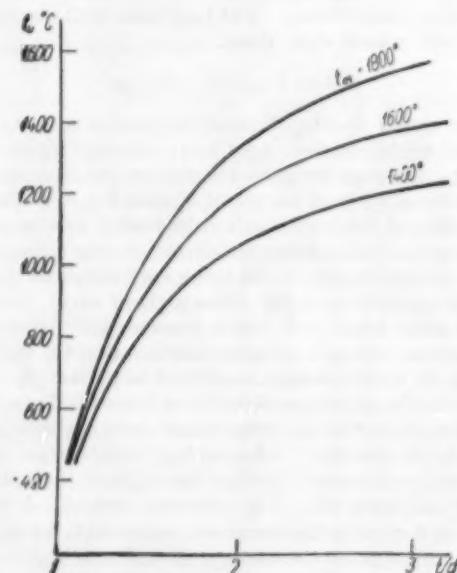


Fig. 4—Graph for determining surface temperature of the refractory behind the tube wall pictures three flame-temperature curves—1800, 1600 and 1400°C—with refractory surface temperatures as the ordinate and the t/d ratio the abscissa.

wall the heat absorption rate increases to several times its value when the slag was on the tube. But this locally increased heat absorption rate does not affect a reduction in flame temperature so the local tube area in a bare tube wall must absorb the entire shock.

It has been found that excessive local heat stresses brought about by alternating heat flow may exceed the yield point of the tube material. Further repeated heat shocks produce a loss of the plastic properties of the metal and failure from heat fatigue. The Twin Branch (2) boiler experience proves this view. There the tubes cracked without preliminary plastic deformation. The reason for the failure was the frequent repeated heat stresses amounting to three times those occurring in refractory-faced tubes.

On the other hand a refractory lining excludes high heat stresses even in thick-walled tubes and dampens the heat shock when the slag layer drops off. A second method of reducing heat shocks is to lessen the thermal blackness of the tube surface. Aluminum, even if oxidized, is less black than oxidized steel tubes. This aluminum coating puts a brake on the heat flow through the tube only until a layer of slag forms on top of it. When this layer forms the tube absorbs radiated heat as well as an ordinary oxidized steel tube. Usually the temperature of a riser tube does not get beyond 400°C so there is no danger of diffusion of aluminum from the surface to the inside of the tube where the perlite in the tube could become graphitized.

Still another method of avoiding tube cracking is to follow the Czechoslovakian and European practice of limiting tube thickness to 7 mm even for boilers of the highest pressure and to tube diameters of 70 mm for all but exceptional cases. This eliminates the danger since

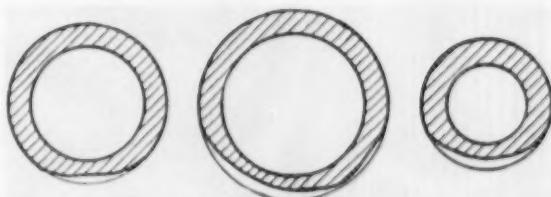


Fig. 5—External etching action on outer surface of boiler wall tubes, above, occurs in spots directly hit by the flame in certain slag-tap furnaces.

heat stresses in tubes of these physical dimensions do not approach critical limits.

External Corrosion of Tubes

External corrosion has been evidenced on some furnace tube walls of slag-tap furnaces. It manifests itself as a weakening of the tube produced by an external etching action, Fig. 5. The evidence indicates this form of corrosion occurs only in slag-tap furnaces, but in both bare tube and refractory-faced tube walls, and is confined to spots directly hit by the flame. It is attributed to compounds formed by the combination of the sulfur in the coal with the tube metal. Reid and Cohen (5) thoroughly investigated this form of tube corrosion.

According to the Reid and Cohen findings the atmosphere at the corrosion spots is usually a reducing one. It appears that coarse coal particles tear off the flame when it hits the tube surface. These particles adhere to the tube surface and burn off slowly with an inadequate supply of oxygen.

In some cases introducing a tertiary air supply eliminated the corrosion. But in the first instance it was necessary to limit the hitting of the tube wall by the flame. A finer grinding of the coal to produce a smaller grain size also proved a successful measure. Similarly the position improved if the pyrite was removed from the coal in the mill. In certain cases a protective oxide coating of the affected surfaces solved the problem.

But for the majority of cases the burners had to be reconstructed to eliminate corrosion. Fig. 6 is an example. Here the corner burner design shown on the left caused intensive corrosion. After rebuilding in accordance with Fig. 6, right, the corrosion effects ceased. Apparently a better distribution of the air and pulverized fuel mixture in the furnace explains the improvement produced by the redesigned burner.

Czech Operating Experience

The first large scale Czechoslovakian slag-tap installation using bare tube furnace walls was a 220-ton/hr steam capacity boiler designed to burn any type of Selsian and Ostrava region coal of a calorific value of about 6000 k cal/kg. This boiler is described in some detail in *Strojirenstvi*, No. 11, 1952 (abridged translation in *Engineers Digest*, February 1954, pp. 65-68). Up to a height of about 6 m from the furnace bottom the walls were of bare tubes with gaps exposing the refractory lining. Above this height the tubes were provided with fins and there was no exposed refractory.

The slag-tap furnace is of rectangular cross-section, 6000 mm by 9000 mm. The burners are corner burners

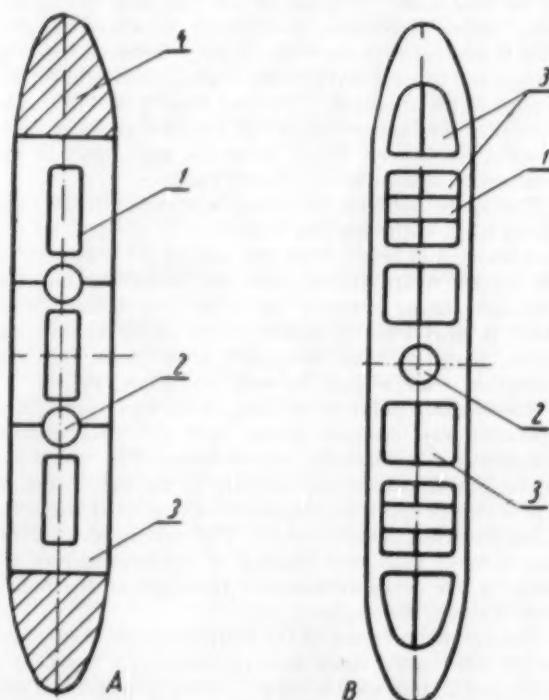


Fig. 6—Corner burner design, left, above, caused intensive corrosion of tube surfaces, Fig. 5. Rebuilding to design, right, above, corrected the trouble.



Fig. 7.—Furnace appearance of combustion space after one month's operation of the first large-scale Czech slag-tap furnace using bare tube walls.

directed toward the center of the combustion space and inclined against the slag bath. Originally, Fig. 3, the walls were made of bare riser tubes of 70-mm dia. with a center spacing of 120 mm to give a gap of about 50 mm between adjacent tubes. The t/d ratio was 1.7. On the outside the wall was faced with refractory bricks of a thickness of about 60 mm. These bricks, bolted to the tube walls, were covered with a thin layer of asbestos and then another layer roughly 60 mm deep, of slag wool. The entire boiler was encased in sheeting of about 3-mm thickness.

After the boiler went into operation an initial melting and slag outflow was obtained while the tubes were still free of slag layer accumulation. Slag outflow began when the steaming output reached 110 tons/hr, or at about 50 per cent of the boiler's rated output. The coal in use at that time had a slag melting temperature of above 1400 C. The temperatures above the slag pool by optical pyrometer readings measured 1600 C to 1750 C. The slag temperatures decreased steeply in the vertical direction which indicated the very intensive cooling effect of the bare tube walls. At 4 m above the furnace bottom, for example, the flame temperature had dropped to less than 1500 C.

The temperature of the lining behind the tubes was not measured. But according to the graph of Fig. 4 this temperature, t_w , should be within the limits of 1080 to 1170 C for flame temperatures, t_m , of 1600 to 1700 C and t/d ratio of 1.7.

After a long period in service a continuous, externally smooth-surfaced, 3- to 10-mm thick layer of slag formed



Fig. 8.—After several months' operation the lining behind the tubes began to melt away and in 4000 hrs was completely gone.

on the tube walls. The deeper into this layer of slag the more porous it became, particularly so where it came close to contact with the tube surface. Between the tube surface and the slag layer, though, was a thin, light brown deposit of the finest ash. The slag layer peeled off easily from the tubes and would fall off during startup or shutdown of the boiler. Fig. 7 shows the appearance of the combustion space after one month's service.

The space between the tubes was found to be only partly filled with slag and then only in the part of the wall above 3 m height from the bottom. In the zone of the highest temperatures above the furnace bottom the refractory lining between the tubes was melted away. After several months operation the lining behind the tubes, began to melt away and after about 4000 hrs. operation it was melted through completely, Fig. 8.

The melting point of the slag at no time during this operating run dropped below 1200 C. This melting temperature, incidentally, was determined by use of the Bunte-Baum method and appears on the graph, Fig. 9. These curves apply to granulated or powdered slag after it has flown out of the furnace. The melting point of this slag is lower than that forming on the tube surface because of the concentration and reduction of the higher iron oxides in the slag pool.

During manufacture of the boiler four adjacent tubes in the combustion space were provided with fins 12 mm thick and 23 mm wide leaving a narrow gap of 3 to 5 mm between adjacent fins. These fins stood up very well in operation. The hot edges of the fins and the refractory beneath them remained intact throughout the operating

experience of Figs. 7 and 8. However, the fins welded on the tubes about 4 m above the slag bath were severely burnt at the edges during this time. These fins were 40 mm wide and 12 mm thick. They were fitted on one side only of the tubes so that the edge facing the furnace was roughly even with the front of the tube.

But because the fins record in general was so good it was decided to reconstruct the furnace by welding fins on

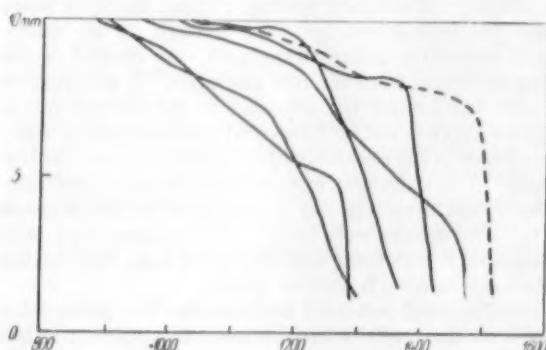


Fig. 9—Melting point of the slag in the zone, Figs. 7-8, was determined by Bunte-Baum method and is pictured above.

all the tubes to close the gaps between tubes and thereby obtain an all metallic cooled surface.

After this reconstruction the boiler went back into operation. The flame temperatures above the bottom remain the same as before. The load point at which slag began to flow, namely 110 tons/hr of steaming output, did not change. The tubes again took on a coating of slag up to a height of 3 to 6 m. This solidified slag, smooth, glassy on the outside surface, dropped off easily. Above the 3- to 6-m height the tube walls remained clean. After about 4000 hrs operation the unit was shut down for inspection. There were no evidences of corrosion and tube surfaces were found to be perfect everywhere.

BIBLIOGRAPHY

1. Mayr, "Removal of The Slag in Liquid Form From Pulverized Coal Combustion Spaces of Slag Tap Furnaces in America," *Feuerungstechnik*, 1930, no. 21/22.
2. Ely and Schueler, "Distribution of Heat Absorption and Factors Affecting Performance of Twin Branch 2500 Psi Boiler," *Trans. ASME*, May 1944.
3. Sokolov, "Analysis of The Operation and The Design of Slag-Tap Furnaces," Symposium "Slag Tap Furnaces" (Russian), *Gosenergizdat*, 1951.
4. "Increase of The Slag Free Output of Steam Boilers," (Russian), *Gosenergizdat*, 1947.
5. Reid and Cohen, "External Corrosion of Furnace Tubes," *Trans. ASME*, vol. 67, 1945, pp. 279-302, and vol. 71, 1949, pp. 951-963.

Research to Guarantee the Gas Industry's Future

The 1954 Annual Report of the director of the Institute of Gas Technology, E. S. Pettyjohn, to the associate members and contributors of that organization carried as its theme the need for research to (1) guarantee the future of the natural gas industry (2) avoid the dangers of regulation for price control by furnishing an adequate supply at competitive costs.

The estimated peak production of 12 trillion CF of natural gas will be reached in 1960. This had been projected originally upon a population of 160 million in the U. S. A. by 1960, increasing to 188 million by 1975. But the nation passed the 162.5 million total in July 1954 and the revised estimate indicates 208 million in 1975. The estimated peak natural gas production of 1960, if not exceeded soon, will be entirely inadequate and be getting worse with each succeeding year.

At the moment the industry has no knowledge of what it will cost to produce added increments of gas, nor what price level will be required to meet the needs. The only solution is to further develop methods of making gas from fossil fuels.

The Carthage Hydrocol plant designed to convert natural gas into carbon monoxide and hydrogen and then into liquid fuels, has been an operational and economic failure. For that reason the industry is doubly cautious about any headlong developments.

Synthesis gas, made by pressure gasification of coal in suspension in the pilot unit at the Crawford Station of The Peoples Gas Light and Coke Co., is now being produced at the rate of 500 CF per hr from an initial one CF per hr rate which indicates definite progress in this method. But today, according to Mr. Pettyjohn, a 1000-ton-a-day coal conversion demonstration plant is needed to work out improvements in design and

operating procedure and thereby better assess progress.

The gasification of coal is essentially an operation for augmenting the supply of natural gas. The gasification of oil, on the other hand, is primarily one of supplementing the natural gas supply for peak loads in winter in localities where the supply of flowing gas is inadequate and underground storage is not available.

Hydrogen is a major need in hydrogasification, and in the processing of natural gas, natural gas condensates and petroleum products, as well as in the production of ammonia for fertilizers and explosives. One of the best sources of hydrogen is coal.

The Institute has developed a process employing expansion gas turbines for the production of hydrogen from coal. They have a somewhat similar method for hydrogen production from light hydrocarbons. In addition they can use heavy oils in place of coal.

The pressure hydrogasification process offers, in the opinion of the Institute, an opportunity for the small gas plant operator to cut labor and material costs and regain competition advantages for his gas in the market. For the longer range coal or heavy oil can be processed depending upon the relative costs and availabilities of these fuels.

Should the Middle East oil fields develop and Bunker C be dumped on the Eastern seaboard a utility could convert to cyclic pressure hydrogasification to develop a high Btu oil or gas. If coal must be depended upon entirely conversion plants can be set up in the coal fields because every gas transmission line of any size in this country crosses a substantial coal field.

The development of these processes will insure the nation of an adequate supply of gas for the next 150 to 200 years at least.

ASME Annual Meeting In Review II—

In the earlier report of the recently concluded annual meeting of the ASME carried in the December COMBUSTION the highlights of the meeting were given and most of the papers of direct interest to the power field. There were, however, a number held over for space reasons that are abstracted below.

Selecting Surface Condensers

In a paper entitled "Approximate Methods for Selection, Sizing and Pricing of Steam Surface Condensers," **William E. Elligen** of Allis-Chalmers Manufacturing Co. presented in chart form some extremely useful data for preliminary design and estimating of this important component in large steam-electric central stations. The paper includes curves showing the relationship of circulating water requirements and amount of steam condensed to required condenser surface for both one- and two-pass surface condensers. Other curves provide information on weight and cost in relation to surface area and of the cost of tubing in relation to area, including variations for several tube materials. Costs of circulating and condensate pumps are plotted in terms of capacity.

By following the procedure outlined in the paper the designer is able to arrive at an approximate price and weight, taking into consideration changes in circulating-water velocity, initial temperature difference, cleanliness factor and circulating-water temperature.

Flow in Pipes

In a paper entitled "Turbulent Flow in the Entrance Region of a Pipe," **Donald Ross** reported on work done at the Ordnance Research Laboratory under a Navy contract in connection with the working section flow studies for the 48-in. water tunnel at Pennsylvania State University. A solution of this problem of turbulent flow is of interest to those engaged in the design of tubular heat exchangers and piping systems. The author presents an analytical solution in the form of equations which yield the relative momentum thickness at any station within ten diameters of the entrance, and from this the pressure drop and heat loss are calculated. The ratio of these quantities to the corresponding values for fully developed pipe flow are found to be practically independent of Reynolds number. Comparison of the theoretical expressions with the few data that are available shows good agreement, confirming the formulas for design applications.

"Effect of a Globe Valve in Approach Piping on Orifice Meter Accuracy" was the title of a paper by **J. W. Murdoch, C. J. Faltz and C. Gregory, Jr.**, of the U. S. Naval Boiler and Turbine Laboratory at Philadelphia, Penna. There are many situations in power plants in which it is impossible to obtain an adequate length of straight pipe to insure a normally turbulent pattern required for metering fluid flow by means of an orifice. The tests reported

in this paper were conducted to show the magnitude of change when less than the minimum straight pipe is used.

The test section consisted of a straight run of 4-in. pipe 147 pipe diameters long, discharging into a condenser, thence to a weighing system. Either steam or water could be introduced into the system. Two sharp-edged thin-plate orifices were used, the control orifice being upstream from the test assembly. A 60-diameter straight run formed the approach to the control orifice. A globe valve could be located at any multiple of three pipe diameters between 6 and 60 upstream from the test orifice. The valve was installed with its stem vertically upward and perpendicular to the plane of the pressure taps. The orifices were constructed in accordance with AGA-ASME standards, and nine pairs were used having beta ratios ranging from 0.30 to 0.85.

The change of indicated flow rate due to a globe valve placed six diameters before an orifice is 2 per cent or less for orifice ratios less than 0.75. For greater ratios the spread of data with or without the valve in the line is of such magnitude that valve disturbance cannot be distinguished from reproducibility. The exact point of no interference is difficult to ascertain. The effect of globe-valve throttling down to 20 per cent relative opening was negligible.

A useful empirical relationship for the flow of saturated boiler water was presented by **Prof. E. S. Monroe, Jr.**, of Cornell University in a paper entitled "Flow of Saturated Boiler Water through Knife-Edge Orifices in Series." Whenever flashing of liquid into vapor takes place, flow formulas for cold water become erroneous. The author conducted experiments in metastable flow in which the variables studied included (1) orifice size, (2) number of orifices in series, (3) presence of solids in water, (4) spacing of orifices, (5) direction of flow, (6) variations in initial pressure and (7) variations in final pressure. Pressures were measured by calibrated bourdon gages and temperatures by means of mercury thermometers in oil-bath wells.

Design of Heat Exchangers

W. C. Beekley of The Whitlock Manufacturing Co. reviewed the current state of process heat-exchanger practice in a paper entitled "The Economics of Heat-Exchanger Design." Over the past twenty-five years continuing heat-transfer research has resulted in greatly added knowledge and more accurate methods of calculation, while development in the physical characteristics of heat exchangers has made possible increasingly comprehensive specifications governing design and construction. Mr. Beekley urged that there should be a clearer recognition of the economically optimum line between "basic mechanical design" and "design for manufacture." Within limits prescribed by thermal analysis and preliminary mechanical design, design for manufacture should be judged more searchingly by economic considerations. Economies may be effected through quantity

production, by optimum selection of forms of materials, through the increased use of jigs, by maintaining uniform criteria for tolerances and inspection, and by increased attention to what might be termed a standardized approach to the relation of practical construction and ideal conditions.

In a paper entitled "Economic Aspects of Shell-and-Tube Exchanger Design" **William C. Beaton** and **Paul A. Taxter** of the M. W. Kellogg Co. presented a cost analysis of the manufacture of an exchanger of the floating-tube-sheet, removable-bundle-type construction. Material and fabrication costs are compared for major elements using steel varying from medium to high tensile strength. The authors presented curves showing cost variations as a function of diameter with pressure and type of plate material as parameters. Bar graphs were also shown to indicate variable labor and material costs for exchangers of varying pressure and shell diameter.

The problem considered in a paper entitled "Optimum Design of Shell-and-Tube Heat Exchangers" by **M. T. Cichelli** and **M. S. Brinn** of the du Pont Company is how to design for minimum annual cost. The general case is solved where the process fluid rate, process fluid temperature change and the coolant inlet temperature are known and both the tube-side and shell-side pumping costs and heat-transfer resistances are appreciable. Solutions are given for the following cases: (1) fixed coolant rate, (2) fixed shell-side velocity, (3) fixed tube-side velocity and (4) fixed surface area. The method of Lagrange multipliers for optimization calculations is demonstrated and used.

Flowmeter Development

In a paper entitled "A New Type of Orifice Flowmeter for Compressible Fluids," **F. D. Ezekiel** of the Massachusetts Institute of Technology developed the theoretical basis for a simple pressure-compensated orifice flowmeter that measures the weight flow of a compressible fluid in the presence of a varying upstream pressure. An experimental model tested at pressures ranging between 200 and 1200 psia indicated flow measurements accurate within a six per cent error margin. A method of simultaneously achieving temperature and pressure compensation is also discussed.

I. O. Miner of Builders-Providence, Inc., presented a paper entitled "The Dall Flow Tube," which is a primary flowmetering device that has been in use in England for some time. Examination of the Dall flow tube gives the impression that a fluid flowing through it would be subject to a very high head loss. Actually, the author pointed out, the loss is lower than for any other known primary device which operates by developing pressures dependent on the acceleration of the fluid. He added that engineers experienced in the art of flow measurement are even more amazed at the remarkably low pressure drop than are the uninitiated. Limitations are encountered in the measuring of flow of fluids containing solids which might settle out in the throat slot, and more straight pipe is required than for some other standard flow-measuring devices. Also the coefficient becomes

variable below a Reynolds number considerably higher than that at which a venturi coefficient starts to vary. Data were provided on coefficients and effects of upstream disturbances for the benefit of researchers and users of Dall flow tubes.

Bourdon Tubes

Although it is one of the oldest and widest used methods of measuring pressure, the Bourdon tube is still generally designed by cut-and-try methods. The ASME Special Research Committee on Mechanical Pressure Elements contributed two papers as a part of its project to change Bourdon tube designing from an art to a science. One of these papers "Sensitivity and Life Data on Bourdon Tubes," was compiled by **H. L. Mason** of the National Bureau of Standards and the chairman of a subcommittee on empirical data authorized by the ASME Special Research Committee in September 1952. The subcommittee was charged with collecting and analyzing such information on the quantitative performance of Bourdon tubes as could be obtained anonymously from manufacturers and users. This information is presented in tabular and graphic form in the paper. Sensitivities are compared with the theories of Wuest, Wolf and Clark-Gilroy-Reissner. Plots of life data as a function of maximum fiber stress are shown for steel and for phosphor bronze.

In a paper entitled "Theories on Bourdon Tubes" **F. B. Jennings** of the General Electric Co. compares theories of Wuest, Wolf and Clark-Gilroy-Reissner with one that he formulated. Results are presented in curves plotting the same dimensionless ratios in all cases. These curves are useful in designing Bourdon tubes of flat-oval, elliptical or pointed-arc cross-section. Experimental data are compared with a curve based on the author's simplified theory, and an empirical curve of similar shape is drawn. Results of analyses of tip travel and tip force are given.

Properties of Metals

Three members of the staff of Battelle Memorial Institute, **R. L. Carlson**, **R. J. MacDonald** and **W. F. Simmons**, presented a paper entitled "Factors Influencing the Notch-Rupture Strength of Heat-Resistant Alloys at Elevated Temperatures." Stress-rupture tests were conducted on notched and unnotched bars of S-816, Inconel "X" Type 550, and Waspaloy alloys at test temperatures ranging from 1200 to 1600 F. The notched specimens had 50 per cent, 60 deg V-notches with root radii ranging from 0.005 to 0.100 in. Results indicated that S-816 alloy was notch strengthened by all of the notches used, in the temperature range from 1350 to 1600 F. Inconel "X" Type 550 was always notch strengthened by all of the notches only at the test temperature of 1600 F. Waspaloy was always notch strengthened by all notches only at the temperature of 1500 F. Factors investigated in the tests included notch geometry, notched and unnotched ductility, modes of deformation and fracture, metallurgical changes and surface conditions. Since the influence of some of these factors can vary from alloy to alloy, it is not feasible to evaluate completely the notch and unnotched stress-rupture be-

havior of a given alloy by any simple method. Instead, the evaluation should be based upon the combined consideration of those factors influential in individual cases.

"The Stress-Rupture Strength of Type 347 Stainless Steel Under Cyclic Temperature" was the title of a paper by E. E. Baldwin of the General Electric Co. Stress-rupture tests were conducted in liquid sodium under constant and cyclic temperature conditions. The former were carried out at temperatures between 1000 and 1200 F, while the cyclic test temperatures ranged from 416 to 1294 F with cycle times from 6 to 12 hr. On the basis of the experimental results it was concluded that the mathematical expressions developed by Robinson for calculating the stress-rupture life of steels under cyclic temperature conditions give results which are only an approximation of the expected life. The deviation of the test from the calculated life was attributed to the transient creep conditions which are not considered in the theoretical formulas. The author cautioned against extrapolating the rupture life determined for this particular stainless steel to other conditions.

In a paper entitled "Design Aspects of High-Temperature Fatigue with Particular Reference to Thermal Stress" by L. F. Coffin, Jr., of General Electric Co. a criterion for fatigue failure was proposed. Based on experiments carried out on test specimens subjected both to constrained thermal cycling and constant temperature strain cycling, the criterion relates the number of cycles

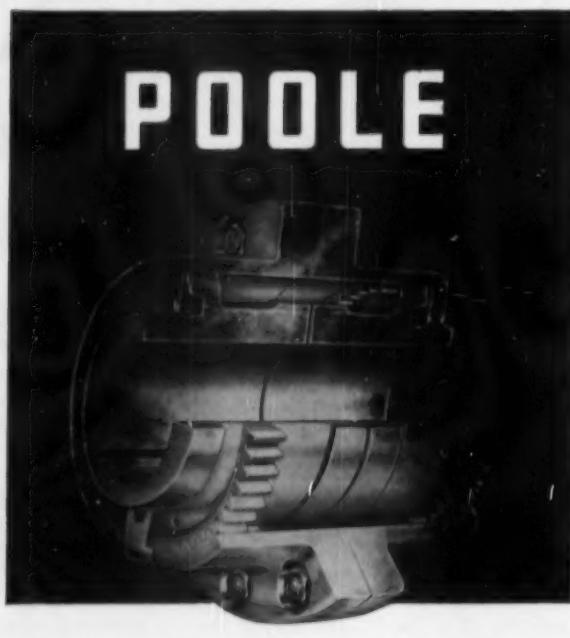
to failure with the plastic strain change per cycle.

Conventional design practice assumes that the material behaves elastically throughout. The use of plastic strain in a design criterion represents a distinct departure from present design philosophy. The new criterion has the advantage that it is possible to predict the life of a certain machine part for a calculated thermal stress, or conversely, the thermal stress permitted for a certain limiting number of cycles of stress.

Heat Transfer

Interest in laminar-flow heat transfer in tubes has arisen in the past primarily in connection with heat-exchanger applications involving oils. However, in a paper entitled "Numerical Solutions for Laminar-Flow Heat Transfer in Circular Tubes" Prof. W. M. Kays, Stanford University, referred to current interest in high-temperature compact heat-exchanger applications where tube diameters are less than $\frac{1}{4}$ in. and densities are low. He pointed out that existing solutions for laminar flow heat transfer in a circular tube are generally based on the assumption of a fully established parabolic velocity profile at the point in the tube where heating begins. For high Prandtl number fluids, such as viscous liquids, this idealization does not restrict the usefulness of the solutions, but in the gas range, near a Prandtl number of 1.00, the assumption of a fully established velocity profile at the tube entrance can, for many applications, lead to a considerable error in predicted performance. The velocity profiles of Langhaar have been employed in numerical solutions for boundary conditions of constant wall temperature, constant wall-to-fluid temperature difference and constant heat input per unit of tube length. Local Nusselt numbers have been evaluated for all three cases, and mean Nusselt numbers with respect to tube length have been evaluated for the first two. Experimental data for the cases of constant wall temperature and constant heat input are shown to be in good agreement with the numerical solutions, while differing substantially from solutions based on the parabolic velocity assumption.

There are many instances in heat-transfer devices where an incompressible fluid is heated or cooled while flowing in a channel along a surface which is curved in the direction of flow. In a paper entitled "The Influence of Curvature on Heat Transfer to Incompressible Fluids," Prof. Frank Kreith of Lehigh University reported on a study of the effect of curvature by comparing heat-transfer coefficients for fluids flowing along a heating surface of concave curvature in the direction of flow with heat-transfer coefficients for a convex heating surface and for a flat heating surface. Using experiment results of wall shear and velocity distribution obtained by Wattendorf, Nusselt numbers were calculated for Reynolds numbers ranging from 10^4 to 10^6 and Prandtl numbers ranging from 0.01 to 100, and for radii of curvature ranging from 0.12 to 1.2 ft. It was found that the heat-transfer coefficient from a heating surface with a concave curvature is considerably higher than for a heating surface of the same curvature in a convex configuration under similar conditions of flow cross-sectional area and flow rate.



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

Power Practices in 1954

POWER developments over the past year have established new highs in all the reportable areas such as: (1) the highest 12-month (Sept. 1953-Aug. 1954) electric energy production ever recorded by the public utilities—up 6.3 per cent over the same period a year ago to 458 billion kwhrs (2) a combined utility and industrial energy production that reached 5.8 per cent above that of the same 12-month span in 1953 to 530 billion kwhrs (3) a utility and industrial generating capacity that aggregated 114,384,545 kw as of August 31, 1954. All the foregoing are based on the latest available Federal Power Commission reports. This same source further puts installed capacity of utility generating plants at 98,079,729 kw on August 31 as compared to 88,634,002 kw August 31, 1953. Industrial generating capacity had reached 16,304,816 kw as of August 31 as compared to 15,825,091 kw on October 31 of 1953. This industrial capacity includes the stationary plants of electric railroads and railways.

Capacity Additions

Manufacture of heavy electric power equipment continues at a high rate according to the Sixteenth Semi-Annual Electric Power Survey of the Edison Electric Institute. This Survey reports a production of new generating units for U. S. electric power systems in 1954 at over 8,600,000 kw delivered during the first nine months and a grand total of about 12,275,000 kw for the full year. As of October 1, 1954, the capacity of new generating units on order and scheduled for shipment amounted to better than 21,000,000 kw.

The E.E.I. Survey further indicated 172 new generating units will supply the expected 12,275,000 kw of new capacity. While this number of new units is the same as that for units placed in service in 1953 the aggregate capacity is about 2,000,000 kw higher. Including the year 1954 the expansion program now scheduled through 1957 calls for placing in service of 456 new generating units with a combined capacity of over 37,000,000 kw.

During the year ending April 30, 1954, the latest available compilation date 29, steam generators of 200,000 lbs per hr capability and larger were purchased for utility installation. This represented an aggregate capability of 20,854,000 lbs per hr or about one-third the amount reported for the year ending April 30, 1953.

Capability of the electric power systems passed the 100,000,000 kw mark some several months ago and it is estimated will reach 104,000,000 kw by the end of 1954, and 129,000,000 kw by the end of 1957.

The peak load for the country as a whole was expected in December and according to estimates would reach to 87,300,000 kw, or 11.2 per cent above the peak load of December 1953. Estimated December peak loads for 1955, 1956 and 1957 are 95,900,000 kw, 102,450,000 kw and 109,100,000 kw, respectively.

Gross margins or capability margins, representing the difference between capability, as listed above, and peak load, are commonly held to be of sufficient magnitude to provide for scheduled maintenance, emergency outages and system operating requirements if practical operating conditions are to be maintained. Insofar as possible

scheduled maintenance outages are programmed for off-peak seasons. For the year 1954 and for the country as a whole the estimated gross margin is a predicted 19.3 per cent and will reach 21.5 per cent for 1955. Both these figures are almost identical with those predicted in the E.E.I.'s Fifteenth Semi-Annual Survey of six months ago.

In Region V of the Federal Power Commission supply regions the summer peaks are appreciably higher than the winter peaks which are the traditionally high ones for the country as a whole. Since Region V embraces Louisiana, Texas, New Mexico, Oklahoma, Arkansas and much of Kansas where air conditioning loads largely influence system peaks the shift to a peak in summer months is not unexpected. Several other areas of the country report somewhat similar experiences. Air conditioning loads in the summer months are drastically changing the shape of the annual load curves for a number of utility companies. On many systems in several areas summer peak loads are closely approaching the winter loads.

As a result the E.E.I. believes utility systems may require larger gross margins than previously to assure adequate generating capability at all times.

Individual System Growths

The larger utilities in the past year dropped off from their most recently established high rates of new equipment purchases. The average size of unit for the 29 reported sales mentioned above for the period ending April 30, 1954 reflected this decrease with a rating of 719,000 lbs per hr as against 982,000 lbs per hr for the previous year. Five of the 29 units, incidentally, were designed for pressure firing using gas and oil as the fuel. There were no pressure fired units for coal as the initial fuel. Also nineteen of the units were of the reheat type.

While the above purchases indicate a temporary slow down in rate of growth of electric generating facilities for the industry as a whole the year 1954 for many individual systems saw new equipment go into service that supplied very sizable additions to previous capacity. The American Gas & Electric Co. System, for example, with its late 1954 additions has increased its electric generating capability by more than one million kw within a 17-month span. On the next two pages several representative new power plants for various utility systems are shown.

The Detroit Edison Co. enjoyed the happy coincidence of dedicating its latest power plant, St. Clair, just 75 years from the day Thomas A. Edison perfected the first practical electric light bulb. This dedication held particular significance in this year since 1954 marked Light's Diamond Jubilee Year. This same company recently ordered the world's largest steam generator, a 2,000,000 lbs per hr, 2450 psi, 1050 F unit, and a 300,000 kw turbine generator, also the world's largest, for its River Rouge Plant.

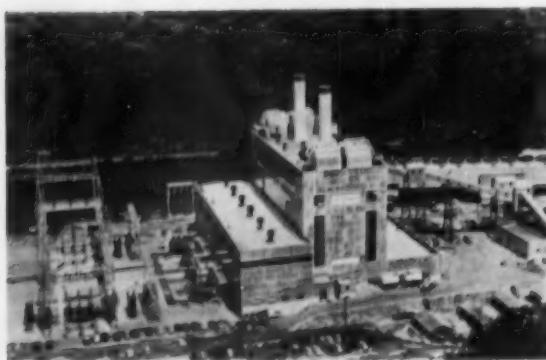
Atomic Energy Plants

The plant capacity scheduled for 1955 to supply energy needs for the many Atomic Energy Commission projects represents a most impressive power bloc. The

Outstanding New



KINGSTON STEAM PLANT of the TVA, when completed, will be the world's largest steam plant with 1,800,000 kw capability. First 150,000 kw unit went into service in February, a duplicate in May, and two others by year's end. 1955 will see plant completion.



SHAWVILLE STATION of Pennsylvania Electric Co., another addition in the general Public Utilities' expansion program, has two 894,000 lbs per hr, 2080 psi, 1058 F with reheat to 1005 F units in service and two more planned.



SUWANNEE RIVER PLANT, Florida Power Corp., is located on the northern end of the system and will serve the company's wholly owned subsidiary, the Georgia Power & Light Co. as well. The plant is of semi-outdoor design with 33,000 kw capability.



URQUHART STATION of the South Carolina Generating Co., wholly owned subsidiary of the South Carolina Electric & Gas Co., marks the eighth generating station of the system which has a total generating capacity of 536,140 kw.

Plants of 1954

OAK CREEK STATION, Wisconsin Electric Power Co., will eventually have four units each serving 120,000 kw turbine generators of the reheat type, operating at throttle pressures of 1575 psig, 1800 psig, and 2000 psig and throttle temperatures of 1000 F, reheated to 1000 F.



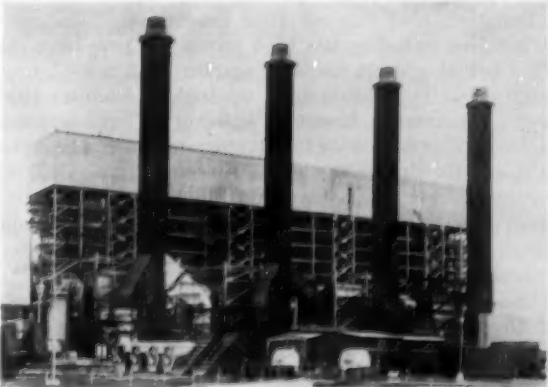
NORTH OMAHA STATION of the Omaha Public Power District was the first modern, reheat-cycle power plant in Nebraska. Its 75,000 kw, 1450 psi, 1000 F turbine generator increased the District's overall capacity by 35 per cent and will contribute 45 per cent of the kwhr requirements.



BARRY STEAM PLANT of the Alabama Power Co. joined the system with two 125,000 kw units during the past year. The plant is designed for ultimate expansion to 1,000,000 kw. Alabama Power Co. now has 890,000 kw of steam-generated capacity and nearly 300,000 kw of hydro.



PITTSBURG PLANT, Pacific Gas & Electric Co., has a generating capacity of 800,000 kw which makes it the largest steam generation station yet built west of the Mississippi. Each of the four boiler units has a steam capacity of 1,080,000 lbs per hr at 2050 psig, 1000 F, TT, and 1000 F reheat.



specially formed electric generating companies—Ohio Valley Electric Corp., Indiana Kentucky Electric Co., Electric Energy, Inc. and South Carolina Generating Co., to name the principals—will contribute about 1,500,000 kw for 1955 service. The heavy power build-up in TVA controlled plants will see close to 2,900,000 kw of additional new capacity on their lines in 1955.

The future needs of all the various atomic energy projects were brought forcibly to the general public's attention by the so-called Dixon-Yates controversy. This particular controversy involved the awarding of a contract to the Mississippi Valley Generating Co., formed by the Middle South Utilities, Inc. and the Southern Co., to supply 600,000 kw to the AEC as against expanding TVA generating capacities to meet this load.

Nuclear Power

The AEC announced in the Spring of this year (1) the awarding of a contract to the Duquesne Light Co. for a pressurized water reactor, (2) the development of a five-year reactor program. The Duquesne contract represents the first central station nuclear reactor which upon completion will be capable of delivering 60,000 kw. The other known techniques for nuclear energy developments are covered in the AEC's five-year program. These involve a breeder reactor of intermediate size, an experimental boiling water reactor with an output of 5000 kw, and two homogeneous reactors, one a scale-up of the Oak Ridge experiment as a preliminary to a 65,000 kw unit that will breed uranium 233 in a blanket of thorium and the second a furtherance of the sodium-graphite technology under study by the North American Aviation Co. Late in the year a contract was awarded the American Locomotive Co. for a portable, or packaged, reactor for U. S. Army studies.

The subject of atomic energy in industry was rather thoroughly explored at a meeting sponsored by the National Industrial Conference Board in Mid-October. Based on projected electric industry growth figures one boiler manufacturer, Foster Wheeler Co., predicted 27,000 mw, or one-half the forecast steam capabilities of 54,000 mw, by 1980 will be nuclear fuel-burning units.

Fuels

Mine output of bituminous coal for 1954 was estimated by Keystone Coal Manual to approximate 390 million tons, just about the same production as that of 1907 (395 million tons) and considerably below the 450 million tons that marked 1953 production. The electric utilities including the TVA properties have been the single bright spot in the coal market with a 1954 consumption of 115 million tons, up slightly from its 1953 level. Predictions, however, indicate 20 million more tons in 1955 than in 1954 for plant operation and building up stocks for the electric generating industry. Coal requirements for the boilers and stockpiles of the new steam generating facilities of the TVA and the atomic energy project suppliers alone will reach an estimated 11.5 million tons.

The fuel oil industry, according to a year-end report by the American Petroleum Institute, showed a decline in demand for residual oil with 524 million barrels required in 1954 as against 565 million barrels in 1953. Imports of crude oil and refined products, however, con-

tinued at about the same rate as established in 1953. Natural gas output, though, moved upward considerably reaching 11 trillion cubic feet or an increase of more, than 368 billion cubic feet over last year.

Certain significant advances have been achieved in the burning of lignite. The recent Minnesota Power & Light Co. experiences in pulverizing high moisture lignite in bowl mill pulverizers and then firing it successfully with standard burners could promote the acceptance of this fuel in those areas where it is readily available.

Industrial plants have been turning more and more to studies leading to the use or reclamation of so-called waste fuels. The spreader stoker has proved a most versatile performer in the problem of handling many of the relatively solid wastes. Chemical recovery boilers in the pulp and paper industry have long-time records in this area and one of 750 ton capacity was recently announced. The refinery industry has developed the CO boiler to successfully solve one of their by-product disposal problems and at the same time reclaim some available heat.

Equipment Development

Perhaps the most outstanding impetus to new power plant design has been the decision on the part of two major utilities, the American Gas & Electric Co. and the Philadelphia Electric Co., to invade the supercritical pressure field. The AGE unit scheduled for the Philo power plant will be a 5500-psig, 1150 F unit built by B & W and the Philadelphia Electric selection, for a site at Eddystone, Penna., will be a 6000-psig, 1200 F, C-E Sulzer Monotube design. This latter unit of twin-furnace construction and two stages of reheat is held to be sufficiently large, 275,000 kw, to prove economical and is expected to return net thermal efficiencies approaching 40 per cent.

This matter of economics will probably provide the key to future decisions on supercritical installations. The very best plants for subcritical service now operate at an overall thermal efficiency of close to 37 per cent. Modern central stations repeatedly report coal rates as low as three-quarters of a pound per kwhr. The indicated efficiency at Philadelphia Electric's supercritical plant promises a heat rate of near 8400 Btu per kwhr or two-thirds of a pound of coal per kwhr.

The turbine industry is, of course, concerned with this invasion of the supercritical pressure range. Westinghouse Electric Corp. has been awarded the contract for the 275,000-kw, tandem compound, four-cylinder, 3600-rpm turbine generator to go into the Philadelphia Electric Co. installation. During 1954 the world's first close-coupled, cross-compound turbine completed a full year's operating service at the Oak Creek Station of the Wisconsin Electric Power Co.

Gas Turbines

There is a growing belief among certain utilities that the gas-turbine generator has features that make it attractive as a base load plant for small and medium sized systems.

Further, many possibilities exist for combining gas turbines with steam turbine cycles to produce improved overall plant heat rates. One manufacturer has developed a number of suggested applications for just such service and the equipment to fit these cycles.

Engineers Peer into Future at Power Show

A long line of newly developed equipment, displayed on December 2-7 in Philadelphia, Penna., by the 21st National Exposition of Power and Mechanical Engineering, forcibly demonstrated the accelerated pace at which industry is carrying on. New designs, such as formerly required years to develop, are now being brought into production in months by some of the larger manufacturers.

The exposition was held as heretofore under the auspices of the American Society of Mechanical Engineers, and management of the International Exposition Company of New York, and staged at the Philadelphia Commercial Museum for the first time.

Symbolizing 75 years of progress in engineering, the ASME exhibit at the Power Show featured a steam engine model of 1879 vintage or earlier, in operation alongside the cut-away model of a gas turbine generator rated at 50 horsepower at 40,000 revolutions per minute. This little unit was designed for portable emergency power use.

Things to come in the everyday application of nuclear power were sharply outlined by several related exhibits at the show. Of primary interest were the Atomic Energy Commission's model of the first nuclear power station, and the Westinghouse Electric Corporation's schematic representation of the reactor-turbo-generator system that will feed power from it into the transmission lines of the Duquesne Light Company.

These models were released by the AEC for viewing by a larger audience than ever before saw anything of the kind. The actual development of the first central-station, atomic-power plant has been under way since approval was granted by the Commission. The reactor is being built by Westinghouse, the turbo-generator is being designed and will be installed by Duquesne, which will subsequently purchase the steam output of the reactor.

Of more immediate interest to scientists and engineers was the offering of a basic reactor designed for selective application in nuclear research. This unique exhibit is a one-sixth scale model, complete in detail, showing a group of standardized components which can be assembled in various ways to serve stated purposes in nuclear research. The exhibitor is now ready to quote costs on the design and construction of reactors for projects approved by AEC. For the first time, industrial concerns, universities and research institutions will have a catalog from which to select standard parts for reactors to produce

neutron and gamma rays, for isotope production, reactor technology, radioactive materials and for biomedical studies.

Advances in combustion engineering were in evidence at the Show and were brought into focus by scale models of new power stations incorporating the latest concepts of design and equipment. One model showed the configuration of the 1954 extension of the Jersey Central Power and Light Company's Raritan River plant. This is the largest steam generating unit in the East utilizing cyclone furnaces. It is rated at 990,000 pounds of steam per hour at 2050 psig and 1050 F. A model of the Mitchell Station of the West Penn Power Company, revealed that that installation is fitted out with no less than 148,000 tons of copper condenser tubes.

Package Boiler Units

The large number of small boiler units at the show testified to the increasing demand for steam and hot water for processing and space heating. Typical "packaged boiler" units are completely self-contained, require neither special foundations nor stacks. They are fully automatic in operation with push-button start and stop, and completely safeguarded. Oil or gas fuel is used and, where heavy oil is to be fired, self-regulating preheaters are furnished.

A remarkable example of compact design coupled with self-regulation carried to the point of automatic starting and stopping, was the automatic "Watchman," developed to save idling costs on a railroad diesel engine. This little package fits a space 18 x 25 x 39 inches, weighs only 250 pounds, and has a rating of 125,000 Btu per hour on 1.25 gph of fuel, with an overall efficiency above 80 per cent. It circulates heated water through the diesel engine jackets at 10 gpm, or thereabouts. The diesels, therefore, are always ready to start without warming up and need not be idled to prevent cooling off during lay-overs. Moreover, when the diesels would ordinarily run cool on light pulls, the "Watchman" cuts in to boost the cylinder wall temperatures and prevent excessive fuel consumption.

Internally-Finned Tubes

A large number of exhibits displayed boiler equipment and supplies, such as insulation, grates and stokers, fire brick and insulation, as well as tubes, gates, gages and all manner of controls. A recent development in water tubes for boilers, also applicable in a variety

of heat-transfer units, is the internally-finned tube. This reverses the familiar application of extended radiation from the outside to the inside of the tube. In boilers, it raises the fire-side to water-side ratio from 1.1 to 4.5. "We have known for a long time what it would do," the exhibitor said, "but it also took a long time to find out how to do it." A special process for brazing the longitudinal fins inside the tubing had to be developed before the conception could be brought into production.

One of the leaders in heavy equipment exhibited a self-cleaning condenser which it considers a major contribution to its field. This incorporates a sluice gate arrangement, which reverses the direction of flow, thereby flushing the debris from the inlet box tube sheets and tube ends, saving hours of down time for cleaning the old way. The cleaning operation is now performed without pause in operation.

Public comfort as well as the protection of plant personnel, explains the exhibition of a number of dust-collecting systems. In one, furnace gases are drawn through cones provided with small louvers through which the gases escape, while dust particles are carried through and trapped at the lower end. In others, the cyclone principle is employed in small-sized multiple units in which dust separation is effected by tangential intakes, that set up powerful centrifugal forces. An elaborate system designed to protect heavy dust-forming processes, operates by means of a multiple screening and scrubbing cycle using sprays of water treated with a dust-wetting agent. One of the more elaborate systems employs electric precipitation in the removal of nuisance dusts as from powerhouse waste gases, but more particularly in recovering material of value, such as metallic fumes and dust from nonferrous smelting plants, carbon black from "furnace black" plants, sulfuric and phosphoric acid in chemical plants, and sodium salts in paper mills.

Mechanical Vacuum Pumps

One of the major industrial organizations observed recently that an increasing number of customer equipment specifications were calling for mechanical vacuum pumps, rather than steam air ejectors to remove air and noncondensable gases from surface condensers. Its reaction was to develop a pump for that purpose, one of which was in operation at the show. It is a two-stage unit consisting of two single-stage rotary pumps of the sliding-vane type, with an intercooler mounted in between. The exhibit was remarkable in that it is the first unit of its type designed specifically for the designated purpose.

Automation was reflected at many

1
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First task of good boiler maintenance is to keep internal metal surfaces clean. Number-1 approach to that task is a simple, direct method of transforming steel from a medium subject to corrosive attack and operating accumulations to one inert to all waters and highly deposit resistant. Number-1 agent for accomplishing that result — and sole product so recognized for thirty-five years by those who design, insure and operate every type of industrial and central-station power plant — is Dampney's trade-marked Number 1 —

Brush-applied to drums, tubes, water-walls, economizers, circulators and associated power equipment exposed to steam and boiler water, Apexior Number 1 provides essential dual protection. The barrier Apexior erects against corrosion provides also a surface that stays clean longer and cleans more easily, thereby assuring more efficient performance in service — less costly maintenance out-of-service. These are the reasons why today Apexior Number 1 remains the Number-1 aid to good boiler house-keeping.

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of the displays. A large number of indicating and regulating appliances are adapted to remote indication or control, as the case may be, by transmission of pneumatic or hydraulic pressures, or by electric currents or impulses. Groups of such appliances are frequently tied into control centers where conditions at scattered points may be observed at one time and corrections made as required in the interflow of processing events. The observations may be "reported" on separate dials or moving charts; they may be combined into a single graph such as that of the scanner displayed by one exhibitor which may be extended to respond to signals from 20 different points, or 200.

Another step in the treatment of signals from multiple points introduced the digital converter, which another exhibitor displayed. This instrument incorporates a group of elemental units, each of which responds to a signal impulse by moving a printing wheel into a corresponding position. A gang of such units constitutes an elementary recording machine. Associated with clock work and other printing wheels, it records the day and the time. Associated with other suitable gearing, it can add, multiply or store data, feed into a computer, code it on punch cards, or actuate an electric typewriter or a teletype machine for permanent records or distant communication.

Variable Speed Drives

Drives, both speed reducing and variable speed, made up a well-filled classification at the Exposition. There were about a dozen displays of electric motored units and an equal number mechanical. One of the latter offered what appeared to be an entirely new solution of the infinitely-variable friction drive problem. Driving and driven members are opposed beveled disks in contact with which are several relatively large balls, held in touch with the disks by an outer floating ring. Contact pressure is maintained by torque-responsive control of the spacing between the disks. The balls are mounted on axles which are varied in angular relation to the driving axis, so that when parallel with it the speed ratio is 1, but when angled the speed is increased or reduced, according to the tilt of the axle. The exhibitor, a well-known maker of gearing drives, is offering the newly disclosed unit in nine sizes, from $\frac{1}{2}$ to 10-hp input and operating efficiencies of 75-90 per cent.

Another exhibitor has gone in heavily for specific applications of the familiar variable-diameter pulley belt drives.

To meet the requirements of plants where operating conditions are rough, one manufacturer showed a "chemical" motor, especially protected from the

effects of corrosion and also explosion proof. To meet the call for speed variation, a second brought forth an a-c adjustable speed drive consisting of a constant speed squirrel cage motor driving an eddy current clutch with excitation from a permanent magnet generator on the output shaft.

A reliable simple, low-cost, adjustable-speed method of operating d-c motors from a-c lines combines the convenience of alternating current power supply with the excellent starting characteristics and good regulation of direct current shunt and compound-wound motors. One new line incorporating these attributes is offered in 16 models for motor ratings from $\frac{1}{8}$ to $1\frac{1}{2}$ hp and is available in compact unit construction, or stripped-down designs for use as original equipment by machine manufacturers.

Detroit Edison Co. Orders World's Largest Equipment

The largest steam turbine-generator in the world, 300,000 kw capacity, was recently ordered for the River Rouge Plant of The Detroit Edison Company from the Allis-Chalmers Mfg. Co. The new unit, a cross-compound design and one of the most economical ever designed and built, will produce a kilowatt hour of electricity for less than three-quarters of a pound of coal. This coal consumption per kilowatt hour is approximately 30 per cent less than the national average. The turbine is designed for an initial pressure of 2400 psig and an exhaust pressure of 1 in. Hg. absolute. Initial temperature is 1050 F. and reheat temperature 1000 F. Both high and intermediate pressure turbines will be on the 3600-rpm shaft. The high-speed generator, which will be rated in excess of 200,000 kva, will have supercharged cooling to both stator and rotor conductors.

Along with this largest steam turbine-generator a new boiler, the world's largest, has also been ordered to supply steam to the turbine. This boiler will supply two million pounds of steam per hour at 2450 psi and at 1050 F.

Foster Wheeler Corporation of New York will build the boiler and its coal pulverizing equipment will be supplied by the Riley Stoker Corporation.



Simplify Your Coal Storage with a

ONE MAN SAUERMAN MACHINE

Here's how a Sauerman machine solves two of your biggest coal storage problems . . .

- ✓ **PROTECTS AGAINST SPONTANEOUS COMBUSTION** . . . "Layers-in" the coal to prevent voids which form dangerous air-pockets or flues.
- ✓ **PROMOTES BETTER LABOR RELATIONS** . . . Operator is in safe, comfortable position overlooking the work area. A satisfied employee eliminates "FLOATING LABOR".

Speed and economy of operation, ease of maintenance and low power consumption compared to tonnage handled are other important advantages provided by Sauerman Stockpiling and Storage equipment.

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SAUERMAN BROS. INC.

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BELLWOOD, ILLINOIS



Conveyors by Sy-Co

The new coal handling system installed by Sy-Co Corporation at the Marine Corps Air Station, Cherry Point, North Carolina. This view taken from the bunker level at the power house.

A Reputation for Dependability
is Our Most Valued Possession



Sy-Co Corporation
ENGINEERS — CONTRACTORS — MANUFACTURERS
7 RIDGE ROAD
LYNDHURST, N. J.



WHY GET PANICKY

over high steam costs?

Just call for



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Mechanical Blending
Assures
Uniform Size-Consist
Assuring
Top Combustion Efficiency
Place a Trial Order

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Chicago 4, Illinois

Personals

Duncan W. Fraser, for 14 years chairman or president of American Locomotive Company, passed away at the age of 70. Mr. Fraser, having retired as board chairman early this year, had served 56 years with American Locomotive Company.

Chain Belt Company has announced the promotion of **Bernard Schneider**, who has had almost 30 years of experience in conveyor engineering work, to chief engineer for the conveyor equipment section.

Bailey Meter Company has just established new district offices in Dallas, Texas and Memphis, Tenn. **F. D. Krusemark** will manage the Dallas office and **R. E. Byers** the Memphis office.

The appointment of **William J. Sparling** to the board of directors has been announced by Chain Belt Co. Mr. Sparling will continue in his present capacity as vice president and manager.

J. E. Summerville, a field service engineer for Hall Laboratories, Inc., in their Birmingham, Ala., district office has been appointed a member of the headquarters staff in Pittsburgh.

Turbine Equipment Co., New York, has advanced **Harold Sinclair** from president to chairman of the board, and **Donald F. Miller** from executive vice president to president in charge of machinery sales.

Laurence R. Lee has been named manager of engineering administration and personnel development in the large steam turbine-generator dept. of the General Electric Co. at Schenectady.

Harold W. Collins, general superintendent of the Detroit Edison Co. electrical system since 1945, has been promoted to special assistant to the manager of engineering, **Howard P. Seelye**. **Delmar D. Chase** moves up from assistant superintendent to the general superintendent of the electrical system. **F. Clifford Pohl** takes over Chase's previous assignment and **Ernest W. Spring**, former staff assistant replaces Pohl.

Edmund B. Besseliere, formerly chief sanitary engineer of the international division of the Dorr Co., has assumed the post of manager for the newly formed industrial wastes division of Kaighin & Hughes, Inc., piping and mechanical contractors.

The election of **Dr. Jacob B. Taylor**, vice president, business manager and treasurer of Ohio State University, to the board of directors of

the American Gas and Electric Co. raises the board membership to 12.

Robert C. Williams, new comptroller of the National Valve and Manufacturing Co., was previously assistant secretary-treasurer of Henry F. Teichmann, Inc.

Dr. Wayne E. Kuhn, is general manager of the Texas Co.'s research and technical department and will have **W. A. McMillan**, as his assistant general manager and **Gus Kaufman**, as manager of operations.

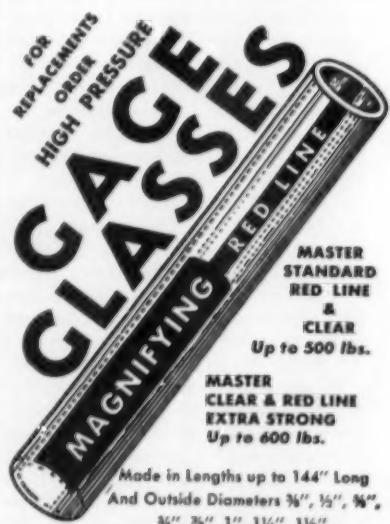
F. Loomis Lamprey has been named manager of mechanical engineering for the construction engineering section of General Electric Co.

John A. Steer has been appointed sales manager of the boiler trim division of Yarnall-Waring Co. from his former post of sales manager for the Philadelphia and New York districts.

James L. Head, mining engineer with Anaconda Copper Mining Co., was re-elected as president of the United Engineering Trustees, Inc., at their fifty-first annual meeting.

Norman Lieblich, general sales manager, was raised to the post of vice president of Kieley & Mueller, Inc.

Harry Engvall, formerly chief engineer of the turbine and gear departments of DeLaval Steam Turbine Co., has been promoted to the post of



executive engineer. His former duties will be handled by John S. Haverstick.

Joseph R. Denton, formerly with Worthington Corp., has been appointed manager of Cochrane Corp.'s newly formed New York district sales office.

The Perfex Corp., has advanced **Irving G. Bohrman** from vice president and general manager of the Radiator Division to president of the board and **Ernest H. Panthofer** from assistant general manager of the Radiator Div. to the position of vice president of the board.

H. D. Emmert, engineer-in-charge of development for Allis-Chalmers Mfg. Co.'s steam turbine section, was appointed assistant chief engineer.

John M. Birkenstock, general manager and director of The Green Fuel Economizer Co., Inc., has retired after 30 years' association.

Jefferson C. Falkner, formerly manager of electric production for Consolidated Edison Co. of New York, has joined Copes-Vulcan Division, Continental Foundry & Machine Co. as an engineering and customer consultant in the development of steam power plant equipment.

Kenneth A. Roe, engineer of Burns & Roe, Inc., has advanced to executive vice president.

Green Fuel Economizer Co., Inc., has announced the appointment of **Kenneth B. Gair** to vice president and general manager.

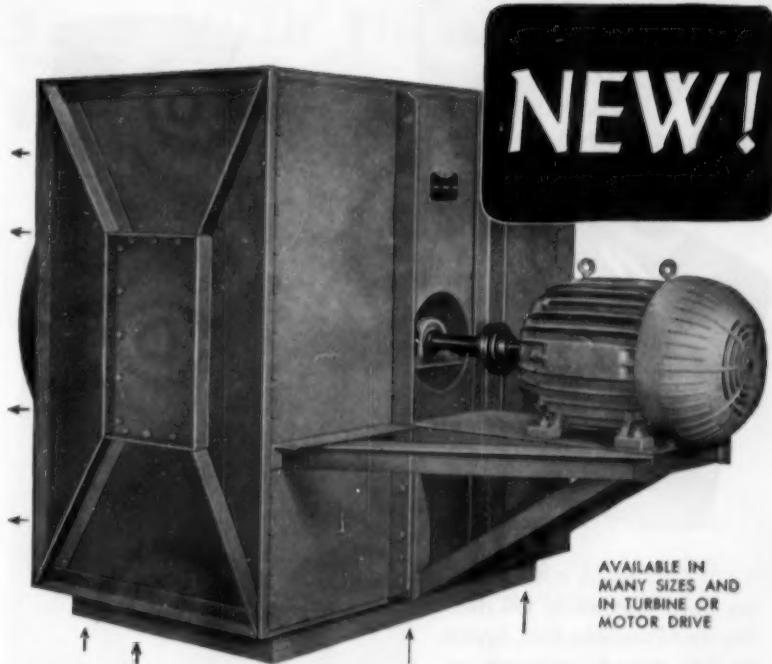
Appointment of **Gustav Schwab, Jr.**, as manager of its Marietta, Ohio, pipe fabrication plant, has been announced by the Machinery Div. of Dravo Corp.

William J. Fadden, Jr., who for a number of years has been in charge of major projects, has been named chief mechanical engineer of The Kuljian Corp.

Le Roi Div. of Westinghouse Air Brake Co. in Milwaukee has advanced **Don S. Permar** from sales manager of stationary air compressors to the newly created post of field sales manager.

Tibor F. Nagey heads the newly formed nuclear division of Martin Aircraft of Baltimore. Key managers in the new division are: **Dr. Robert Spooner**, nuclear research and development, **James Dunlop**, nuclear manufacturing, **William A. Maxwell**, nuclear production engineering, **Howard F. Dunlap**, nuclear products development and **Russell L. Hopping**, marketing research.

Allison C. Neff, vice president of Armclo Drainage & Metal Products, Inc., has been nominated as candidate for president of the National Society of Professional Engineers.



WING PACKAGE DRAFT INDUCER FOR POWER PLANTS

**MOTOR AND FAN DESIGNED AS
ONE COMPLETE REMOVABLE UNIT**

MAKES INSTALLATION EASIER

**FACILITATES INSPECTION AND
MAINTENANCE**

SAVES SPACE

**ELIMINATES WATER COOLING
OF BEARINGS**

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TOP, BOTTOM OR SIDES**

**NO LUBRICATION REQUIRED—
BEARINGS PRE-SEALED**



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Factories: Linden, N. J.
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Automatic
OIL PUMPING
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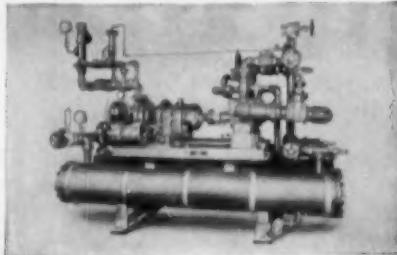
*Completely
Coordinated*

Every detail part of an Enco Automatic Oil-Heating-and-Pumping Unit System is designed, assembled, checked and tested to make sure that it functions as an element of a completely coordinated unit. The sizes of pipes, fittings, valves and other elements are correctly proportioned for the efficient, dependable operation of the unit as a whole. All hand controls are visible and within reach of the operator for quick starting, stopping or cross-over reconstructions between duplicate heaters and pumps. Adjustments and cleaning are similarly simplified.

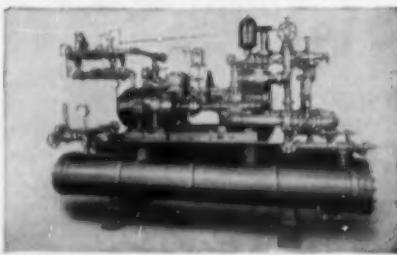
Single or duplicate heaters and electric or steam-driven pumps are used. Interconnected duplicate units give full capacity with either pump or either heater. Capacities range from 100 to 5000 G. P. H. of heavy bunker oil.



Two Horizontal Duplex Piston Type Steam Pumps and two fuel oil heaters—capacity 15 G. P. M. at 250 lb. pressure with either pump or heater.



One Turbine and One Motor Driven Pump and two fuel oil heaters. Capacity 30 G. P. M. at 150 lb. pressure with either pump or heater.



One Horizontal Duplex Piston Type Steam Pump and one Motor Driven Pump and two fuel oil heaters. Capacity 25 G. P. M. at 300 lb. pressure with either pump or heater.

BULLETINS ON REQUEST

OB-37 On oil burning, pumping and heating equipment.

OB-38 Instruction book on care and operation of oil-burner installations.

THE ENGINEER COMPANY

75 WEST STREET  NEW YORK 6, N.Y.

Harry A. Winne, retired vice president of General Electric Co., has been awarded the 1954 John Fritz medal by the Founding Engineering Societies.

Daniel H. Dykins has been appointed manager of utilities of The Kuljian Corp.

Executive vice president Henry V. Erben has been appointed group executive in charge of the new distribution group of General Electric Co. with executive vice president Robert Paxton succeeding Mr. Erben as group executive in charge of the apparatus group.

For notable scientific achievement in the field of solid fuels, John F. Barkley, fuels technologist in the office of the chief, fuels and explosives division, Bureau of Mines, was presented the Percy Nicholls Award in Pittsburgh on October 28, 1954. Mr. Barkley has served 35 years with the Bureau of Mines and is credited with saving the Government millions of dollars in the purchase of coal and in the selection of efficient fuel-burning equipment for Federal establishments.

Business Notes

Jervis C. Webb, pres. & general mgr., Jervis B. Webb Co., Detroit, Mich., was elected president of the Conveyor Equipment Manufacturers Association at its 21st annual meeting. R. C. Sallenberger was re-elected executive vice president and will be chief staff executive in the association's Washington, D. C., headquarters. Fred S. Wells was elected vice president, E. E. Boberg, treasurer and R. B. Mass, secretary.

Enterprise Heat and Power Company of Chicago has announced that they will serve as the executive Midwest factory branch for the Heat-Timer system of heat regulation. This was made after 1½ years of testing the system in the Chicago area.

Secretary of Interior Douglas McKay announced the five Bureau of Mines Regions that will replace the present nine upon completion of the current Bureau reorganization. The five new regions will be in Albany, Oreg., San Francisco, Calif., Denver, Colo., Bartlesville, Okla., and Pittsburgh, Pa. Under the reorganization all bureau operations in a region, except for those dealing with health, safety, coal-mine inspection, and helium, will be directed from regional headquarters.

At a special meeting of the Board of Directors of Penn Industrial Instru-

ment Corp. the board voted to accept a proposed plan for merger of that company with Burgess-Manning Co. The board of directors of Burgess-Manning Co. previously approved the merger. This is subject to shareholders of both companies approval and to that of various legal details by the legal counsel.

By a surprisingly heavy total vote a majority of eligible voting members of The American Society of Heating and Ventilating Engineers expressed their approval of changing the name of the sixty-year old engineering society to American Society of Heating and Air-Conditioning Engineers, Inc. The new name has been filed with the secretary of state of the State of New York and became effective November 23, 1954.

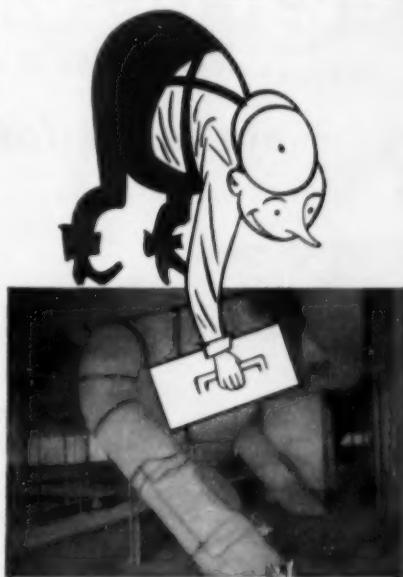
M. A. Ellsworth, vice president and director of sales for the Fluor Corp., Ltd., announced the opening of a Denver, Colo., district sales office. Under the management of L. O. Calkins, district sales manager, the Denver office will serve the states of Colorado, Utah, Montana, Wyoming, and New Mexico plus Southeast Idaho and the country of El Paso, Texas.

Under the terms of an agreement with a substantial majority of the shareholders in the Griscom-Russell Co., the General Precision Equipment Co. will exchange a portion of their stock for stock in Griscom-Russell. The agreement, if consummated will result in a transfer of control to General Precision Equipment.

The coal unloader of the Jersey Central Power and Light Co., Raritan River Plant, is the first unloading tower or bridge in the world to use magnetic amplifiers and the first to use the new Westinghouse Electric Corp. high-speed (3600 rpm) Rototrol speed regulators. The unloader operates on a 33-second cycle to handle 600 tons of coal per hour. Bucket operation is managed by two 155-hp d-c motors and a 44-hp d-c motor operates the trolley.

The newest and largest steam electric power generating unit of the Southern California Edison Co., including the largest boiler of its type in service west of the Mississippi, has just recently gone into commercial operation at its Redondo Steam Station, Redondo Beach, Calif. Designed and constructed by Stone & Webster Engineering Corp. in collaboration with Edison Co. engineers, this unit adds 160,000 kw capacity to the Edison system. This brings the combined Redondo Steam Station to 448,000 kw capacity and the total of Edison steam plants to 1,144,500 kw. (For other developments see pp. 49-52).

Save With This Matchless ONE-COAT SUPER FINISH



Use One-Coat Super Finish Stic-Tite on flanges, valves, fittings, flat or curved surfaces of boilers, fans, tanks and other equipment, whether indoors or exposed to the elements.



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*In these 12 states OLD BEN COAL
provides LOW COST STEAM!
...NOT just a low price
at destination!*

Your combustion problems...your equipment and load cycle...dictate the recommendations of Old Ben fuel engineers. Only Old Ben employs all three accepted coal cleaning methods—Air, Water and Heavy Media Separation—and Old Ben produces a far wider than usual range of sizes...assuring a product designed for your exclusive needs.

Coal reserves of highest quality sufficient for many decades...four originating railroads...generations of engineering know-how and the reputation that goes with it...all these are Old Ben plus values.

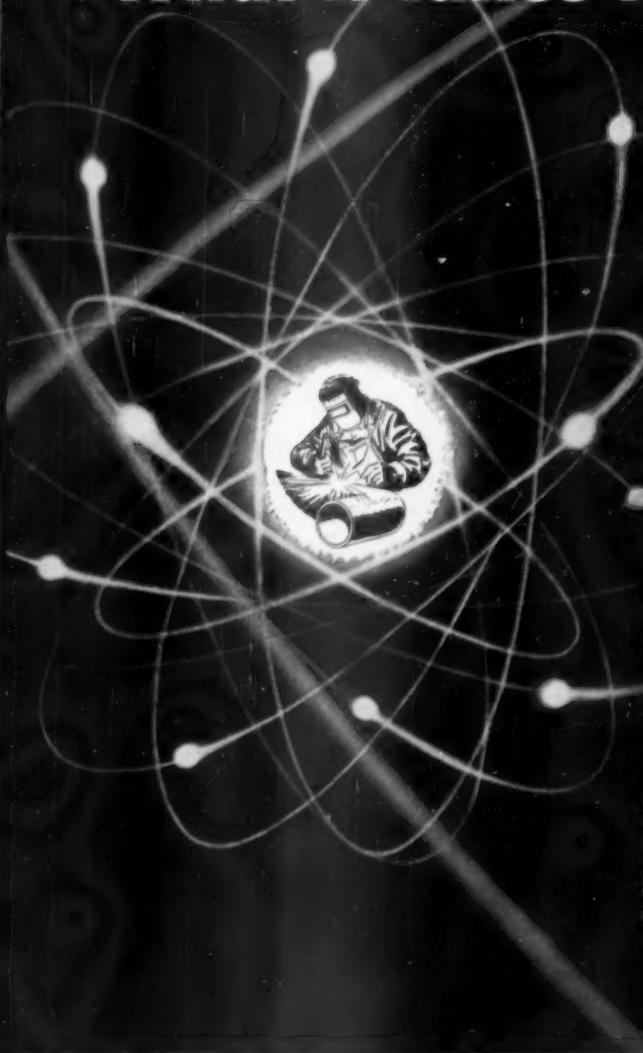
May we consult with you on your energy requirements?

Old Ben Coal Corporation

Chicago 4, Illinois



What it Takes to Pipe the Atom



No power piping or chemical process piping job is too large or complex for The M. W. Kellogg Company. At the AEC's billion-dollar gaseous diffusion plant, Paducah, Kentucky, it entails the installation of 3,450,000 feet of tubing and pipe for the main process, auxiliary, and instrument piping, and represents 17,500,000 total man-hours—850,000 engineering, 2,600,000 welding. M. W. Kellogg also will test the system prior to use.

M. W. Kellogg's responsibility started long before a single length of pipe could be put in place. It included an on-the-site welding school—to help all contractors master unfamiliar techniques, and a temporary pipe fabricating and fitting shop costing one million dollars. Once work was started, the control system to prevent product contamination was so strict that not even a thumbprint was allowed on the interior of the pipe.

The size and complexity of the Paducah assignment...the outstanding labor relations and safety records achieved...help explain why The M. W. Kellogg Company is pre-eminent in the engineering and construction of jobs ranging from public utility piping systems to complete refineries and chemical processing plants.

M.W. Kellogg

ENGINEERING FOR TOMORROW

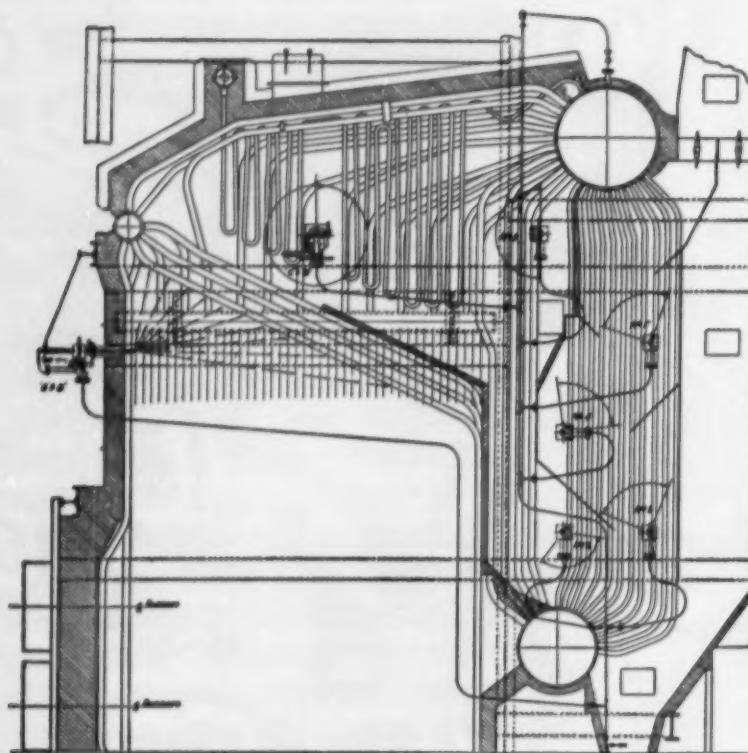
THE M. W. KELLOGG COMPANY, NEW YORK 7, N. Y.

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CLEAN HEATING SURFACE and LOW MAINTENANCE



460 p.s.i. PULVERIZED COAL FIRED BENT TUBE BOILER

- The high temperature zone, first pass screen tubes are cleaned by BAYER RETRACTABLE GUN TYPE MASS-FLOW CLEANERS located in the front furnace wall. When not in use the nozzle is retracted from the furnace, where it is away from the heat, thus assuring long and efficient service life.
- The superheater is cleaned by BAYER LONG RETRACTABLE MULTI-NOZZLE CLEANERS. The elements are advanced for cleaning and after the cleaning cycle are entirely withdrawn from the furnace. By the use of such Retractable Cleaners heating surface is kept clean at all times, and element maintenance is negligible.
- The rear banks of boiler tubes are cleaned by BAYER conventional revolving elements.

The soot cleaner system illustrated emphasizes the fact that the soot blower in every case should be engineered to suit the operating conditions of the boiler to which it is applied.

BAYER engineering is at your service at any time. We will gladly co-operate with you in order that the best equipment may be correctly applied to efficient cleaning of heating surface under the operating conditions in your plant.

Over the years a large Mid-West Utility Company has used BAYER SOOT BLOWERS. The first installation was made over twenty years ago. Eleven repeat orders for BAYER SOOT BLOWERS to equip new boiler installations have been ordered. The boiler illustrated at the left was installed last year. The record of efficiency, dependability and service demonstrated by BAYER EQUIPMENT in past years resulted in BAYER being selected for the new boiler.

The Bayer Company

ST. LOUIS, MISSOURI, U.S.A.

**FOR HIGHEST FIRST AND
FINAL VALUE BUY BAYER**



THIS BURNER RING KEEPS FLAME PATTERNS PERFECT!

Slag build up is costly. It distorts flame patterns, reduces firing efficiency, prolongs down time, and boosts maintenance costs.

But it won't be a problem here! This Combustion Engineering Type R Burner—which will soon be firing pulverized coal—has a ring that won't soften even at extremely high temperatures. The CARBOFRAX® silicon carbide refractories used are too hard and too dense to give slag a foothold. *They keep flame patterns perfect!*

You can find a way to increase *your* firing efficiency. Just write today for our free booklet, "Super Refractories." Address Dept. E15, Refractories Div., The Carborundum Company, Perth Amboy, N. J.

Burner Rings of CARBOFRAX Super Refractories

- Won't soften, even at extreme temperatures, so slag never fuses to the burner ring.
- Take brutal punishment—with fewer repairs, replacements, and shutdowns (an out of line burner will have little effect on this ring).
- Resist abrasion, heat shock, and flame erosion.
- Eliminate flame deflecting slag fingers.
- Insure against tube damage by falling slag.

CARBORUNDUM

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ARE CLOGGED LINES LIKE THESE CUTTING YOUR WATER SUPPLY?

*Over 1½ Miles of Buried Water Line
Chemically Cleaned IN PLACE by Dowell Service*



You don't have to dig up water lines in order to clean them! Take the case of a major railroad that had over 8600 feet of *buried* water lines, ranging from 2 to 12 inches in diameter. The capacity of these lines had been greatly reduced by scale deposits. Dowell Service used liquid solvents to clean all the lines, *in place*, during a period of only six days with a minimum interruption in service.

Dowell Service offers *fast*, effective chemical cleaning of pipelines of all kinds—water lines, disposal lines and product lines. And, whether these lines are underground or above, indoors or out, no digging or dismantling is necessary. Dowell solvents are designed to dissolve the accumulated deposits, and are introduced through regular connections. Because they are liquid, Dowell solvents reach wherever steam or water can flow, cleaning places

inaccessible by other methods—angles, curves, valves, complicated surfaces and hook-ups. *Experienced* Dowell engineers do the job using Dowell-designed truck-mounted pumps, mixers and control equipment.

Many other types of equipment can also be cleaned chemically by Dowell. If you have boilers, condensers, evaporators, bubble towers, water wells or other operating equipment where deposits are reducing capacity, let Dowell Service *save you time and money in maintenance cleaning!*

FIND OUT ABOUT CHEMICAL CLEANING! There are many places in your plant where Dowell Service can clean equipment faster and better than out-dated mechanical methods. Call your nearest Dowell office for a fact-filled book. Or write direct to Tulsa, Dept. A-25.

DOWELL SERVICE

Over 100 Offices to Serve You with Chemical Cleaning for:

Boilers • Condensers • Heat Exchangers • Cooling Systems
Pipe Lines • Piping Systems • Gas Washers • Process Towers
Process Equipment • Evaporators • Filter Beds • Tanks

Chemical Services for Oil, Gas and Water Wells

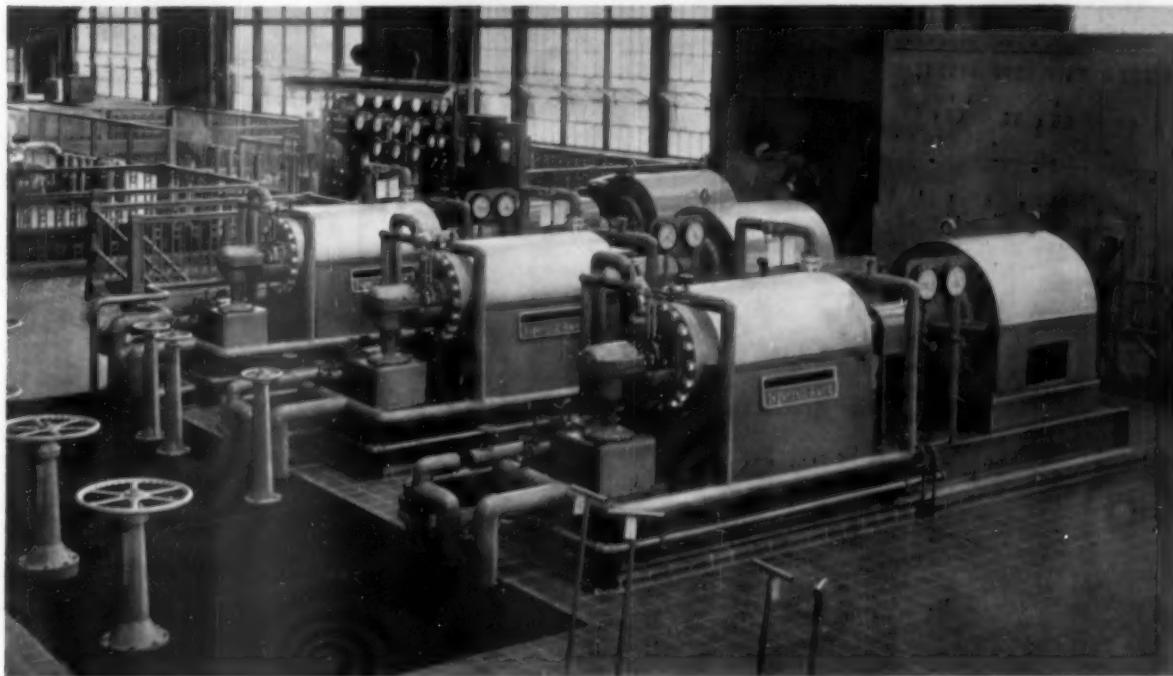
DOWELL INCORPORATED
Tulsa 1, Oklahoma

DOWELL

A Service Subsidiary of
THE DOW CHEMICAL COMPANY

STANTON STATION of THE SCRANTON ELECTRIC CO.

served by Ingersoll-Rand boiler feed pumps
of proven dependability and high efficiency



*Three 475 gpm, 1735 psig 10-stage Class CHTA
units chosen for 40,000 kw Unit No. 3 . . .*

Ingersoll-Rand "double-case" boiler feed pumps have stamina and endurance to meet the needs of The Scranton Electric Company and



Also installed at Stanton Station: two Ingersoll-Rand Class 4GT two-stage horizontally-split centrifugals in ash sluice service. Gilbert Associates, Inc. were consulting engineers for the installation of Unit No. 3.

many other utilities throughout the nation.

A vertically-split inner assembly is enclosed in a heavy forged steel outer housing. As a result of this sturdy cylindrical "double-case" construction—and other I-R features such as leak-proof metal-to-metal joints, stainless steel fits, and thrust-free running balance—these pumps have an unusual record of long-trouble-free service in high pressure installations. Maintenance has been simplified—and reduced to a minimum.

See your nearest I-R representative for further information on Ingersoll-Rand pumps and other power plant equipment of proven dependability.

Ingersoll-Rand

Cameron Pump Division

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10-12

PUMPS

CONDENSERS

COMPRESSORS

AIR & ELECTRIC TOOLS

ROCK DRILLS

You can have **Double Safety**
through **Double Supervision**
of your boiler water levels



**Thousands of boilers like yours
protected by this Safety Team**

Depending on one source of water level checking is shortsighted these days. Make *doubly sure* with the Reliance Safety Team. The Alarm Water Column with sensitive float-operated mechanism faithfully warns with a whistle blast if level reaches unsafe low or high positions. But operators rarely let that happen when they have constant access to the accurate EYE-HYE Remote Gage reading, located conveniently at eye-level on panel or wall.

EYE-HYE's green indicating fluid is now more evenly illuminated by a fluorescent lamp. And EYE-HYE can be equipped to control lamps or horns in still other plant locations. Make your boiler extra safe like the many in steam plants everywhere enjoying Safety Team water level supervision. Write the factory or your nearest Reliance representative.

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The name that introduced safety water columns....in 1884

Reliance®
BOILER SAFETY DEVICES

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Delaware Power & Light specifies

Richardson

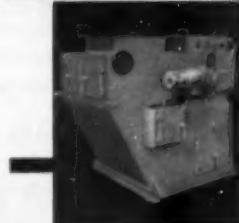
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Like many progressive utilities, Delaware Power & Light Company selected Richardson Automatic Coal Scales to maintain a constant check on boiler efficiency in their new generating station. The bank of Richardson Model 39's shown now handles this responsibility.



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This is another example of industry's trend toward establishing its own higher standards for nuisance abatement. Research-Cottrell, which has made more fly ash installations than any other company, cites the following comparison:

In the period from 1923 to 1939 only 11% of its power plant customers specified fly ash collection efficiency of 95 to 98%. In recent years, that 11% has risen to fully 90%.

One reason, of course, is the generally increasing emphasis on community relations. Another factor is that far-sighted companies are anticipating stricter smoke regulations. They are anxious to install equipment that will end their smoke problems now and also prevent such problems from occurring in the future.

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Read—in Bulletins FA and MI—about Cottrell equipment and the Research-Cottrell's MI Rapper. This device eliminates rapping puffs and enables the precipitator to maintain, continuously, its high collection efficiency. Write for your copies today.

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